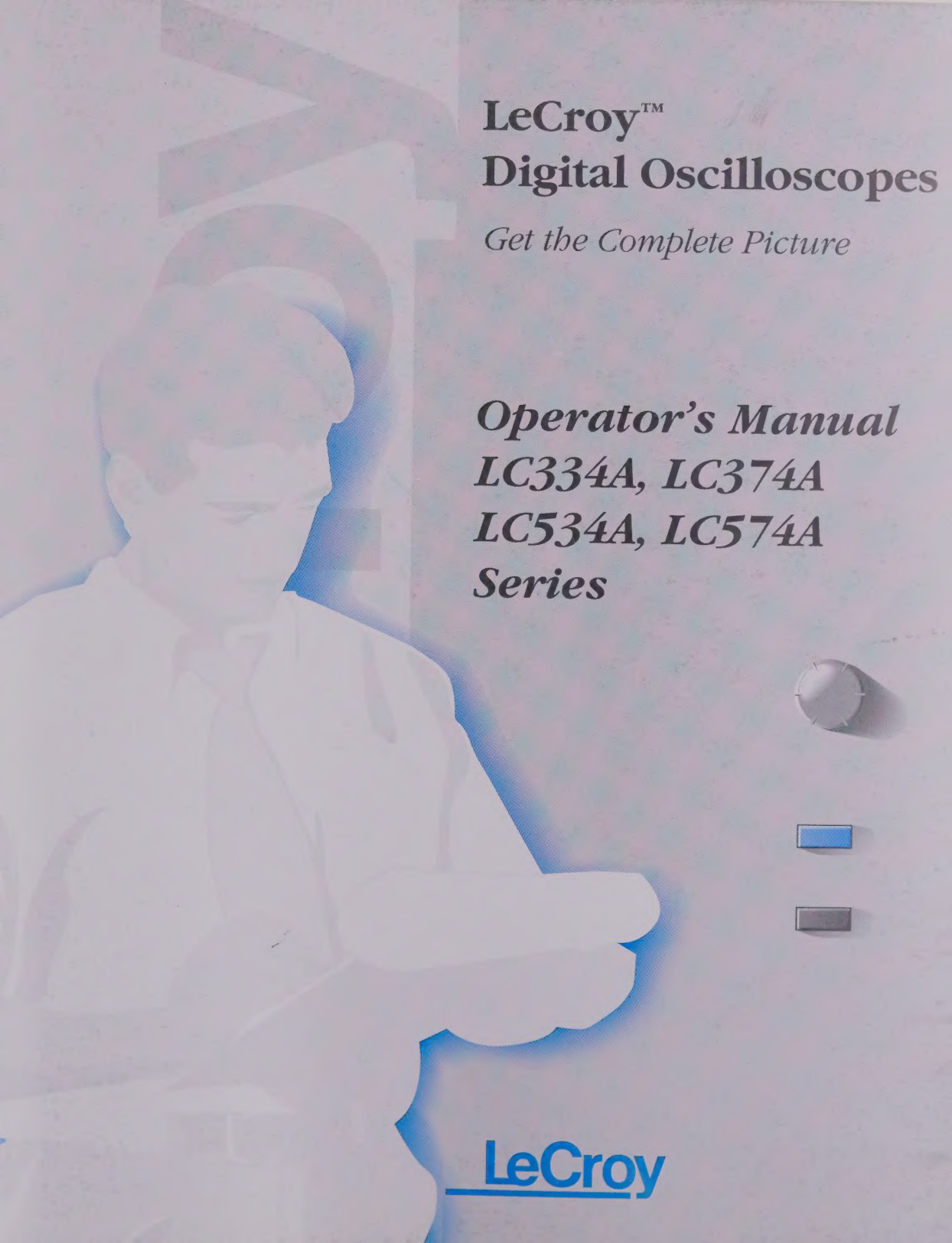
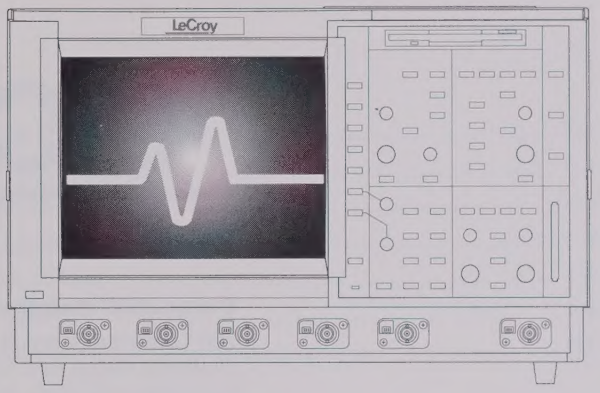
LeCroy™ Digital Oscilloscopes

Get the Complete Picture



Operator's Manual LC334A, LC374A LC534A, LC574A Series

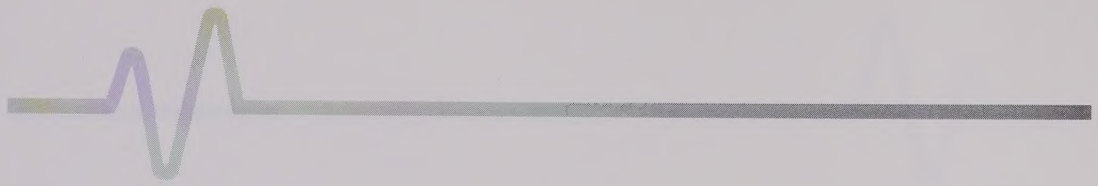
LeCroy



Operator's Manual

LeCroy Color Digital Oscilloscopes

Revision D — August 1997



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Product and Client Care

As Soon As Your Scope is Delivered

We recommend you thoroughly inspect the contents of the scope packaging at once. Check all the contents against the packing list/invoice copy shipped with the instrument and the list on page 1–3 of this manual. Unless LeCroy is notified promptly of a missing or damaged item, we cannot accept responsibility for its replacement. Contact your national LeCroy Customer Service Department or local office immediately.

Warranty

LeCroy warrants its oscilloscope products for normal use and operation within specifications for a period of three years from the date of shipment. Calibration each year is recommended to ensure in-spec performance. Spares, replacement parts and repairs are warranted for 90 days. The instrument's firmware has been thoroughly tested and is thought to be functional, but is supplied without warranty of any kind covering detailed performance. Products not made by LeCroy are covered solely by the warranty of the original equipment manufacturer.

In exercising its warranty, LeCroy will repair or, at its option, replace any product returned within the warranty period to the Customer Service Department or an authorized service center. However, this will be done only if the product is determined by LeCroy's examination to be defective due to workmanship or materials, and the defect has not been caused by misuse, neglect or accident, or by abnormal conditions or operation.

The client will be responsible for the transportation and insurance charges for the return of products to the service facility. LeCroy will return all products under warranty with transport prepaid.

This warranty replaces all other warranties, expressed or implied, including but not limited to any implied warranty of merchantability, fitness, or adequacy for any particular purpose or use. LeCroy shall not be liable for any special, incidental, or consequential damages, whether in contract or otherwise.

Product Assistance

Help on installation, calibration, and the use of LeCroy equipment is available from the LeCroy Customer Service Department in your country (*see contact numbers on the back cover and following the index*).

Maintenance Agreements

We provide a variety of customer support services. Maintenance agreements give extended warranty and allow our clients to budget maintenance costs after the initial three-year warranty has expired. Other services such as installation, training, enhancements and on-site repairs are available through special Supplemental Support Agreements.

Keeping You Up to Date

LeCroy is dedicated to offering state-of-the-art instruments, continually refining and improving the performance of our products. Because of the speed with which physical modifications may be implemented, this manual and related documentation may not agree in every detail with the products they describe. For example, there might be small discrepancies in the values of components affecting pulse shape, timing or offset, and — infrequently — minor logic changes.

However, be assured the scope itself is in full order and incorporates the most up-to-date circuitry.

We frequently update firmware or software during servicing to improve scope performance, free of charge during warranty. We will keep you up to date with such changes, through new or revised manuals and other publications.

But you should retain the original manual for future reference to your scope's unchanged hardware specifications.

Service and Repair

Please return products requiring maintenance to the Customer Service Department in your country or to an authorized service facility. LeCroy will repair or replace any product under warranty free of charge. The customer is responsible for transportation charges to the factory, whereas all in-warranty products will be returned to you with transportation prepaid. Outside the warranty period, you will need to provide us with a purchase order number before we can repair your LeCroy product. You will be billed for parts and labor related to the repair work, and for shipping.

How to Return a Product

Contact your country's Customer Service Department or local field office to find out where to return the product. All returned products should be identified by model and serial number. You should describe the defect or failure, and provide your name and contact number. And in the case of products returned to the factory, a Return Authorization Number (RAN) should be used. The RAN can be obtained by contacting the Customer Service Department.

Return shipments should be made prepaid. We cannot accept COD (Cash On Delivery) or Collect Return shipments. We recommend air-freighting.

It is important that the RAN be clearly shown on the outside of the shipping package for prompt redirection to the appropriate LeCroy department.

What Comes with Your Scope

The following items are shipped together with the standard configuration of this oscilloscope:

- Front Scope Cover
- 10:1 10 MΩ Passive Probe — *one per channel*
- ProBus™ Single-Channel Adaptor
- *Two* 250 V 6.3 A Fuses
- AC Power Cord and Plug
- Operator's Manual
- Remote Control Manual
- *Hands-On Guide*
- Performance Certificate
- Declaration of Conformity
- Warranty

Note: ***Wherever possible, please use the original shipping carton. If a substitute carton is used, it should be rigid and packed so that that the product is surrounded by a minimum of four inches or 10 cm of shock-absorbent material.***

Key Points in the Complete Picture

One of a new generation of DSOs built on an innovative technology platform, this color digital oscilloscope is designed to give the complete picture in waveform capture, viewing and analysis.

Leading specifications include:

— **500 MHz** *(LC334A, LC374A) or* **1 GHz** *(LC534A, LC574A)* Bandwidth

— **2 GS/s** *(LC334A, LC374A, LC534A) or* **4 GS/s** *(LC574A)* Single-Shot Sample Rate

— **10 GS/s** Digitizing Rate for repetitive signals.

— **8 million points** *combined* Acquisition Memory *(L models)*

— **100 000, 500 000** *(M models) or* **2 M points** *(L models)* Acquisition Memory *per channel*

— **96 MHz** PowerPC™ 603e Microprocessor

— **8–64 MB** System RAM

— **9-inch** (170 mm x 125 mm) Color Display area, **10-inch CRT**

— **Analog Persistence™** (analog speed *and* digital flexibility)

— **Full Screen** (expands the waveform to fill the *entire* screen)

— **SMARTMemory** System Management

— **SMART Trigger™** Acquisition, including **Exclusion Trigger**

— **170 MB** Portable Hard Disk option

— **ProBus™** Intelligent Probe System

— **Internal Graphics Printer** — optional *(LC334A, LC374A, LC534A) or* standard *(LC574A).*

See Appendix A *for the complete specifications on all models.*

General Designed Capabilities

Each of the oscilloscope's four channels has an 8-bit ADC (Analog–to–Digital Converter). Combining two channels doubles the scope's sampling rate, while combining all four channels increases the original rate by four times*.

Processors

The central processor is a PowerPC™ microprocessor, which performs the scope's computations and controls its operation. A wide range of peripheral interfaces allow remote control, storage and printing. A support processor constantly monitors the front-panel controls, rapidly reconfiguring setups. Data processing is also rapid, with data being transferred to the display memory for direct waveform display or stored in the reference memories (*see below*).

ADCs

The instrument's multiple ADC (Analog–to–Digital Converter) architecture ensures absolute amplitude and phase correlation, maximum ADC performance for multi-channel acquisitions, large record lengths and excellent time resolution.

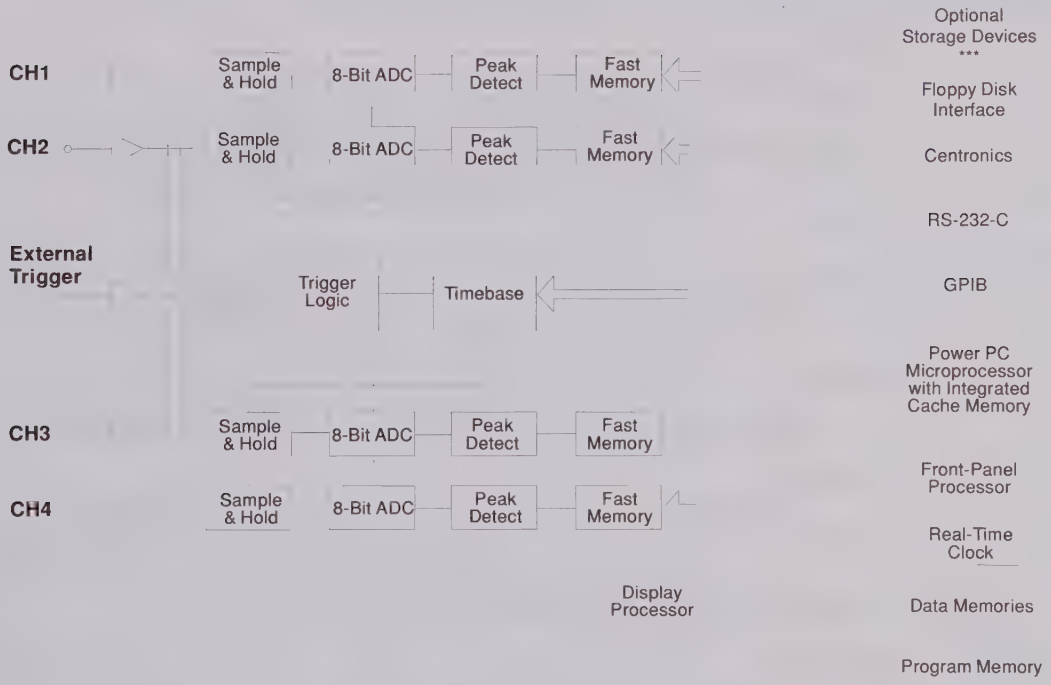
Memories

The copious acquisition memories simplify transient capture by producing long waveform records that capture even when trigger-timing or signal-speed is uncertain. Combining two or four channels also increases the acquisition memory length. There are four memories for temporary storage, and four more for waveform zooming and processing.

RIS

Repetitive signals can be acquired and stored at a Random Interleaved Sampling (RIS) rate of 10 GS/s. RIS is a high-precision digitizing technique that enables measurement of repetitive signals to the instrument's full bandwidth, with an effective sampling interval of 100 ps and measurement resolution of 10 ps.

* In conjunction with an external adapter.



BLOCK DIAGRAM

Trigger System

The Trigger System offers an extensive range of capabilities, selected according to the character of the signal, using on-screen menus and front-panel controls. In standard trigger mode these menus and controls enable the selection and setting of parameters such as pre- and post-trigger recording, and sequence and roll modes. The trigger source can be any of the input channels, line (synchronized to scope's main input supply) or external. The coupling is selected from AC, LF REJect, HF REJect, HF, and DC; the slope from positive and negative. (*See* Chapter 9.)

Automatic Calibration

The oscilloscope's automatic calibration ensures an overall vertical accuracy of typically 1% of full scale. Vertical gain and offset calibration take place each time the volts/div setting is modified. In addition, periodic calibration is performed to ensure long-term stability at the current setting.

Display System

The display's interactive, user-friendly interface is controlled by push-buttons and knobs (*see* Chapter 5).

The large display area, set in a 10-inch Raster Scan CRT, VGA (Video Graphics Array), presents waveforms and data using Advanced Color Management. This color management system's overlap-mixing and contrast-enhancement functions assure that overlapping waveforms remain distinct at all times. Both pre-set and personal color schemes are available. (*See* Chapter 13.)

Up to four waveforms can be displayed at once, while the parameters controlling signal acquisition are simultaneously reported. The screen presents internal status and measurement results, as well as operational, measurement, and waveform-analysis menus.

The Analog Persistence™ function offers display attributes of an analog instrument with all the advantages of digital technology. The Full Screen function expands complete waveforms to fill the entire screen. (*See* Chapters 12 *and* 13.)

A hard copy of the screen is produced by pressing the front-panel screen-dump button(*See* Chapter 14).

Manual or Remote Control

Despite being a truly digital instrument, the scope has a front-panel layout and controls that will be familiar to users of analog oscilloscopes. Rapid instrument response and instant representation of waveforms on the high-resolution screen add to this impression.

Four front-panel setups can be stored internally and recalled either manually or by remote control, thus ensuring rapid front-panel configuration. When the power is switched off, the current front-panel settings are automatically stored for subsequent recall at the next power-on.

The oscilloscope has also been designed for remote control operation in automated testing and computer-aided measurement applications — operations described in the *Remote Control Manual*. The entire measurement process, including cursor and pulse-parameter settings, dynamic modification of front-panel settings, and display organization, is controlled through the rear-panel GPIB (IEEE-488) and RS-232-C ports.

Installation for Safe and Efficient Operation

The oscilloscope will operate to its specifications if the operating environment is maintained within the following parameters:

Operating Environment

- Temperature.....5 to 40 °C (41 to 104 °F).
- Humidity.....Maximum relative humidity 80 % RH (non-condensing) for temperatures up to 31 °C decreasing linearly to 50 % relative humidity at 40 °C
- Altitude.....2000 m (6560 ft)

The oscilloscope has been qualified to the following EN61010-1 category:

- Protection Class.....I
- Installation (Overvoltage) Category.....II
- Pollution Degree.....2

Safety Symbols

Where the following symbols or indications appear on the instrument's front or rear panels, or elsewhere in this manual, they alert the user to an aspect of safety.

Symbol	Meaning
	CAUTION: Refer to accompanying documents (for Safety-related information). ***See elsewhere in this manual wherever the symbol is present, as indicated in the Table of Contents.***
	CAUTION: Risk of electric shock.
	On (Supply).

Symbol	Meaning
	Off (Supply)
	Earth (Ground) Terminal
	Protective Conductor Terminal
	Chassis Terminal
	Earth (Ground) Terminal on BNC Connectors
WARNING	Denotes a hazard. If a WARNING is indicated on the instrument, do not proceed until its conditions are understood and met.

WARNING

Any use of this instrument in a manner not specified by the manufacturer may impair the instrument's safety protection.

The oscilloscope has *not* been designed to make direct measurements on the human body. Users who connect a LeCroy oscilloscope directly to a person do so at their own risk. Use only indoors.

Power Requirements

The oscilloscope operates from a 115 V (90 to 132 V) or 220 V (180 to 250 V) AC power source at 45 Hz to 66 Hz. No voltage selection is required, since the instrument automatically adapts to the line voltage present.

Fuses

The power supply of the oscilloscope is protected against short-circuit and overload by means of two 250 V AC "T"-rated fuses. The fuses are located above the mains plug.

Disconnect the power cord before inspecting or replacing a fuse. Open the fuse box by inserting a small screwdriver under the plastic cover and prying it open. For continued fire protection at all line voltages, replace only with fuses of the specified type and rating (*see above).*

Ground

The oscilloscope has been designed to operate from a single-phase power source, with one of the current-carrying conductors (neutral conductor) at ground (earth) potential. Maintain the ground line to avoid an electric shock.

None of the current-carrying conductors may exceed 250 V rms with respect to ground potential. The oscilloscope is provided with a three-wire electrical cord containing a three-terminal polarized plug for mains voltage and safety ground connection. The plug's ground terminal is connected directly to the frame of the unit. For adequate protection against electrical hazard, this plug must be inserted into a mating outlet containing a safety ground contact.

Cleaning and Maintenance

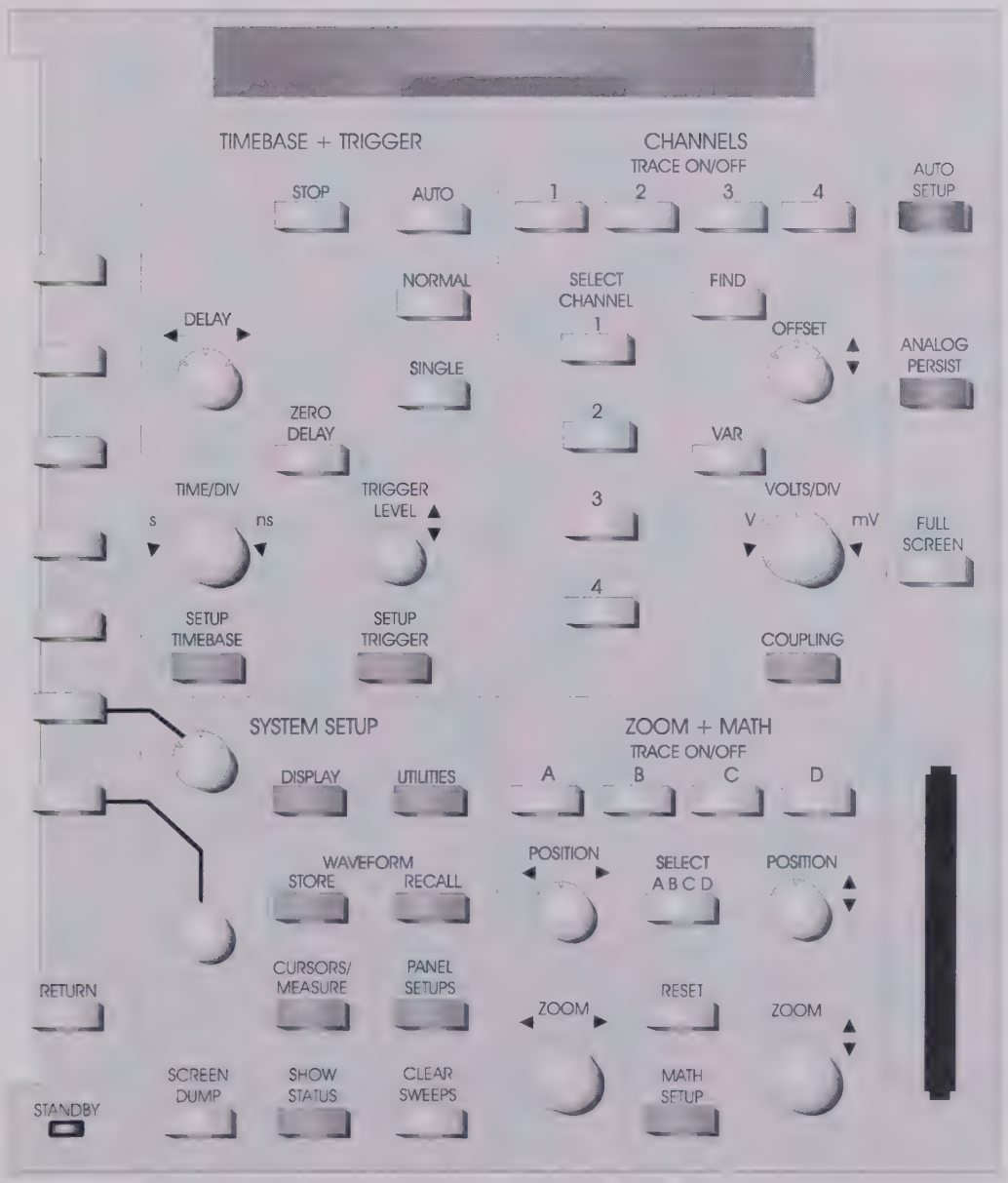
Maintenance and repairs should be carried out exclusively by a LeCroy technician (*see Chapter 1*). Cleaning should be limited to the exterior of the instrument only, using a damp, soft cloth. Do not use chemicals or abrasive elements. Under no circumstances should moisture be allowed to penetrate the oscilloscope. To avoid electric shocks, disconnect the instrument from the power supply before cleaning.

CAUTION

Risk of electrical shock: No user-serviceable parts inside. Leave repair to qualified personnel.

Power On

Connect the oscilloscope to the power outlet and switch it on using the power On/Off button, located near the left-hand corner of the instrument below the screen. After the instrument is switched on, auto-calibration is performed and a test of the oscilloscope's ADCs and memories is carried out. The full testing procedure takes approximately 10 seconds, after which time a display will appear on the screen.


TIMEBASE + TRIGGER
CHANNELS
TRACE ON/OFF
STOP
AUTO
1
2
3
4
AUTO SETUP
NORMAL
SELECT CHANNEL
FIND
DELAY
OFFSET
ANALOG PERSIST
SINGLE
ZERO DELAY
VAR
TIME/DIV
s
ns
TRIGGER LEVEL
VOLTS/DIV
V
mV
FULL SCREEN
SETUP TIMEBASE
SETUP TRIGGER
COUPLING
SYSTEM SETUP
ZOOM + MATH
TRACE ON/OFF
DISPLAY
UTILITIES
A
B
C
D
WAVEFORM STORE
RECALL
POSITION
SELECT A B C D
POSITION
RETURN
CURSORS/ MEASURE
PANEL SETUPS
ZOOM
RESET
ZOOM
SCREEN DUMP
SHOW STATUS
CLEAR SWEEPS
MATH SETUP
STANDBY

Front-Panel Controls and their Attributes

Illustrated on the previous page, the front control panel is divided into four main groups of buttons and knobs: TIMEBASE + TRIGGER, CHANNELS, ZOOM + MATH and SYSTEM SETUP. Other buttons control on-screen menu selection and special features.

AUTO SETUP — This singular blue button automatically adjusts the scope to acquire and display signals on the input channels. *See Chapter 12.*

ANALOG PERSIST — Unique as the green of its button on the panel, the Analog Persistence™ feature offers analog-like speed and depth of display information with digital data-manipulation flexibility. *See Chapters 12,13.*

FULL SCREEN — redraws the grid to fill the entire screen. *Chapter 12.*

Menu Buttons & Knobs — seven untitled buttons, vertically aligned beside the screen, which control on-screen menu selection along with the two knobs found in the SYSTEM SETUP group. Each menu button, and the knobs associated with two of them (indicated by connecting lines on the panel), controls the menu to its immediate left on the screen. *See the following section and Chapter 12.*

CHANNELS — controls that enable selection of displayed traces and adjustment of vertical sensitivity and offset. *See Chapter 6.*

TIMEBASE + TRIGGER — These buttons and knobs allow direct adjustment of time/division, trigger level and delay, and access to the "TIMEBASE" and "TRIGGER" menu groups. *Details: Chapters 7,8,9.*

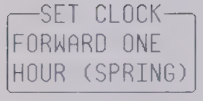
SYSTEM SETUP — The dark-gray, menu-*entry* buttons that dominate this group of controls (and that are represented in each of the other groups), provide access to the main on-screen menus and the acquisition, processing, and display modes of the instrument. *See next section and Chapter 12.*

ZOOM + MATH — controls that enable trace selection, movement, definition, and expansion with Zoom and Math functions. *See Chapters 10,11.*

Choosing and Navigating in Menus

Menus

The menus are arranged in a column at the right-hand edge of the on-screen display area. Each menu contains information and the choice of scope functions offered by it. Where a menu has a title, this is set in the top of its frame. The name of the set of menus to which those displayed belong — "TIMEBASE" for example — is shown at the top of the column of displayed menus. On-screen text unbounded by menu boxes is for information only.



Each menu contains a list of items or options — functions to be selected, variables modified — or when it is activated performs a specific action. The menus that perform an action are indicated by capitalized text, *as in the example shown at left.*

Accessing, Moving between and Selecting from Menus

When a menu-*entry* button is pressed, the set-up configuration for its particular functions is immediately displayed on-screen as a set of menus. Once accessed, controlling these menus becomes the role of the menu buttons, as well as the two associated knobs (*illustrated at left*).

A menu button is active whenever there is an on-screen menu beside it. Active menu buttons correspond to and control the menu displayed to their immediate left. Along with the two menu knobs (each controlling the menu to which it is linked), these buttons are used either for selecting menus, particular items from menus, for moving up or down through menu lists, or for changing the values listed in the menus.

Some menus, known as primary, have secondary menus beneath them whose existence is indicated by a heavy outline or shadow, *as illustrated at left.* Pressing the corresponding menu button reveals and activates these 'hidden' menus. Pressing the RETURN button will re-display the primary menu.

***Note:** When the oscilloscope is placed in a remote state, the REMOTE ENABLE menu will be displayed. It will contain the command "GO TO LOCAL", activated by menu button if the action is possible. This is the only manual way to turn off the REMOTE ENABLE menu. The scope need not be in remote state to accept remote commands.*

Normally, changing a menu value changes the screen, because the new value is immediately used in acquisition settings, processing or display.

Setting Menu Options

The activated choice from the menu is highlighted when selected, *as illustrated at left.* Press the corresponding menu button and the field advances to highlight–select the next item on the menu. However, if there is only one item on a menu, pressing its button will have no effect.

Where a menu is associated with one of the two menu knobs, turning this knob in one direction or the other will cause the highlighting selector to move either up or down the list of permitted values.

Menus that extend along the length of two menu buttons can be operated using both these buttons. Pressing the lower of the two will move the highlighting forward — down the list — while pushing the upper one will move the selector back up the list.

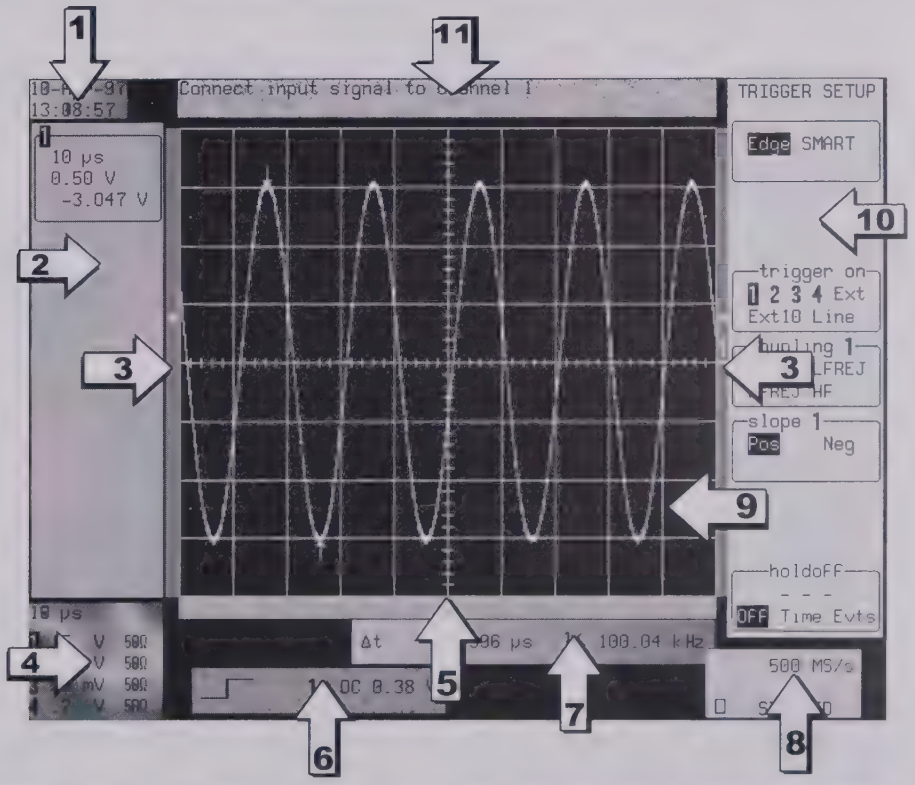
An arrow at the side of a menu frame, *as illustrated in the second-from-top menu on this page*, indicates items not visible but present either above or below the displayed part of the list. When there are two arrows, one pointing up and the other down, the items not shown exist both above and below. Arrows indicate the direction in which the highlighting selector will move relative to its button. No arrows will be shown if the selection is at the beginning or end of the list.

As in the examples immediately at left, some menu button and knob combinations control the value of a continuously adjustable variable. The knob is then used to set its value, while the button either selects a value or makes a simple change in it.

Still other button and knob combinations control the value of several continuously adjustable variables, with the menu knob used to set the value and the button to highlight it.

Screen Topography

The sections of the screen, or fields, *indicated and described below*, contain a variety of useful information or provide access to specific commands and functions.



1 – Real-time Clock Field — powered by a battery-backed real-time clock, displays the current date and time.

2 – Displayed Trace LabelField — contains trace labels: the identity of each displayed trace, its timebase and volts/div settings, and cursor readings when applicable.

3 – Trigger Level Field — contains the trigger-level indicator (symbolized by small arrows) on both sides of the grid, and the ground indicator for each channel — line and number — on the right-hand side of the grid.

4 – Acquisition Summary Field — contains the common timebase setting, and the vertical gain, probe attenuation and coupling for each channel. The selected channel is highlighted.

Note: The Displayed Trace label shows the acquisition parameters set when the trace was captured or processed, whereas the Acquisition Summary field indicates the present setting.

5 – Trigger Delay Field — indicates the trigger delay, symbolized by the upward-pointing arrow at bottom of the grid. The delay can be adjusted from zero to ten grid divisions (pre-trigger), or zero to –10 000 (post-trigger) off-screen. Pre-trigger delay appears as an upward-pointing arrow at the appropriate position in the field, while post-trigger is given as a delay in seconds.

When the relative-time cursors (twin arrows) are activated by selection from the "MEASURE" menu group, the field displays the time interval between the two cursors. It also displays the frequency corresponding to 1/(time interval).

6 – Trigger Configuration Field — displays the trigger source, slope, level and coupling. When applicable, additional information is given, such as hold-off by time or by number of events, or logic states. A simple icon indicates the overview of trigger conditions. With certain menus, this field is replaced by a special help field.

7 – Time and Frequency Field — displays time and frequency relative to cursors. For example, when the absolute-time cursor (the cross-hair) is activated by selection from the "MEASURE" menu group, this field displays the time between the cursor and the trigger point.

8 – Trigger Status Field — contains the sample rate and the trigger re-arming status (AUTO, NORMAL, SINGLE, STOPPED).

During an acquisition the small box at left of the re-arming status will indicate when an intermediate acquisition occurs. This feature helps monitor the trigger rate before the waveform is reconstructed.

For NORMAL status, the message "SLOW TRIGGER" appears in the field when needed.

For slow acquisition, the message "SLOW UPDATE" appears as a reminder that it will take time for a new waveform to be completed.

The region just to the left of the trigger status field may contain messages indicating lengthy processes such as FFT calculations or screen dumps under way.

9 – Grid — displays traces from the acquisition or reference memories. A dual- or quad-grid presentation can also be selected.

10 – Menu Field — can contain up to seven different menus.

11 – Message Field — used to display a variety of messages, including warnings, indications and titles indicating the instrument's current status.

For a detailed description of the display fields and controls, and the role of color, see Chapter 13, Color and Display.

General Instrument Reset: ***Simultaneously press the AUTO SETUP button, the top menu button, and the RETURN button. The scope will revert to its default power-up settings.***

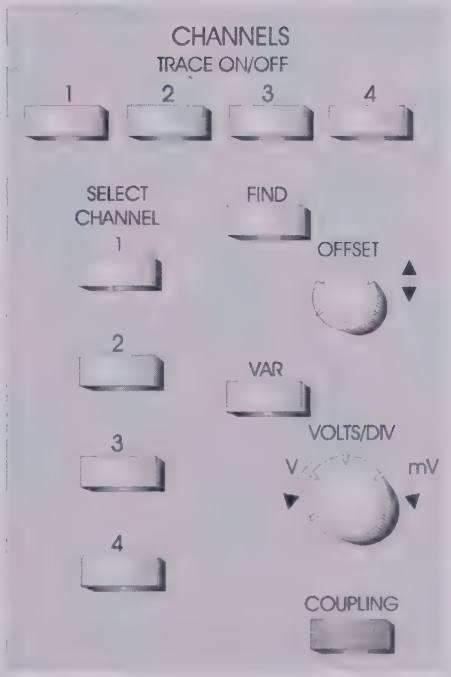
Channel Controls

When pressed, the TRACE ON/OFF buttons cause the corresponding channel trace — Channel 1, 2, 3 or 4 — either to be displayed or switched off. When a channel is switched on, the OFFSET and VOLTS/DIV controls will then be attributed to this, the *active* channel.

The SELECT CHANNEL buttons are used to attribute all *vertical* controls to a channel, independent of whether or not it is the channel displayed. The channel's number is highlighted in the Acquisition Summary field (*see Chapter 5,* Screen Topography).

— *vertically* positions the active channel.

— automatically adjusts offset and volts/div to match the input signal in the active channel.



— selects the *vertical* sensitivity factor either in a 1–2–5 sequence or continuously (*see VAR, below*). The effect of gain changes on the acquisition offset can be chosen from the "SPECIAL MODES" menu.

— allows the user to determine whether the VOLTS/DIV knob will modify the vertical sensitivity in a continuous manner or in discrete 1–2–5 steps.

The format of the vertical sensitivity in the acquisition summary field (bottom left of screen) shows whether the VOLTS/DIV knob is operating in *continuous* or *stepping* mode.

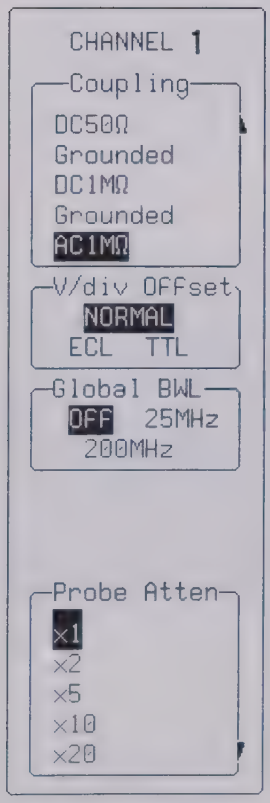
— menu-entry button that accesses the "Coupling" menus (*see next section*).

Coupling

Coupling Menus

Press COUPLING **for access to selection of:**

- **Coupling and grounding of each input channel**
- **ECL or TTL gain, offset and coupling preset for the channel shown**
- **Bandwidth limiter for all channels**
- **Probe attenuation of each input channel.**



Coupling

Used to select the input channel's coupling. If an overload is detected, the instrument will automatically set the channel to the grounded state. And the menu will show "**OVERLOAD**".

V/div Offset

When NORMAL is highlighted, pressing the corresponding menu button sets the offset, Volts/div, and input coupling to display ECL signals. Press the button a second time and the settings for TTL signals are given. And a third time returns the settings to those used at the last manual setup of the channel.

Global BWL

To turn the bandwidth limit "**OFF**" or "**ON**".

The bandwidth can be reduced from 500 MHz or 1 GHz, to either 200 MHz or 25 MHz, or 30 MHz (–3dB), depending on the model (*see* Appendix A). Bandwidth limiting can be useful in reducing signal and system noise or preventing high-frequency aliasing, reducing — for example — any high-frequency signals that may cause aliasing in single-shot applications.

Note: This command is global and affects all input channels.

Probe Atten

Sets the probe attenuation factor related to the input channel (*see following for probe details*).

Probes and Probe Calibration

Probe Calibration

To calibrate the probe, connect it to one of the input channels' BNC connectors. Connect the probe's grounding alligator clip to the CAL BNC ground and touch the tip to the inner conductor of the CAL BNC. The CAL signal is a 1 kHz square wave, 1 V p-p.

Set the channel coupling to DC 1 MΩ, turn the trace ON and push AUTO SETUP to set up the oscilloscope. If over- or undershoot of the displayed signal occurs, the probe can be adjusted by inserting the small screwdriver, supplied with the probe package, into the trimmer on the probe's barrel and turning it clockwise or counter-clockwise to achieve the optimal square-wave contour.

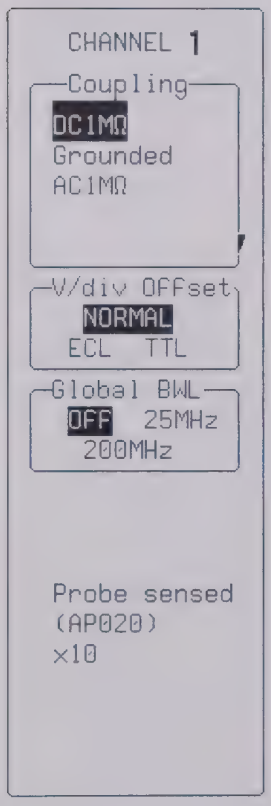
More On Coupling

In the AC position, signals are coupled capacitively, thus blocking the input signal's DC component and limiting the signal frequencies below 10 Hz.

In the DC position, all signal frequency components are allowed to pass through, and 1 MΩ or 50 Ω may be chosen as the input impedance.

The maximum dissipation into 50 Ω is 0.5 W and inputs will automatically be disconnected whenever this occurs. An indication of the overload can be found in the Acquisition Summary Field and in this menu. The overload condition is reset by removing the signal from the input and selecting the 50 Ω input impedance again.

ProBus™ System



LeCroy's ProBus system provides a complete measurement solution from probe tip to oscilloscope display. This intelligent interconnection between LeCroy oscilloscopes and a growing range of accessories is achieved via a six-wire bus following Phillips' I^2C protocol. It provides major benefits over standard BNC or even probe-ring connections:

- **Autosensing the probe type**, eliminating all the guesswork — and the errors — from manually setting attenuation or amplification factors, and proper input coupling.
- **Transparent gain and offset control** right from the front panel — particularly useful for FET and current probes.
- **Gain and offset correction factors** are uploaded from the ProBus EPROMS on FET probes and **automatically compensated** to achieve fully calibrated measurements.

As shown in the example at left, when a FET probe is used, "Probe sensed", automatically appears to indicate settings. When other ProBus probes are used, this menu is redefined.

Timebase + Trigger Principles and Capabilities

Timebase Modes

The following sampling modes are available:

- **Single-Shot**
- **Random Interleaved Sampling (RIS)**
- **Roll.**

Which of these is chosen will depend on the timebase setting. For all timebases where either Single-Shot or Roll Mode can be used, the acquisition memory can be subdivided into user-defined segments to give:

- **Sequence Mode.**

Single-Shot

Single-Shot is the digital oscilloscope's basic acquisition technique and all other timebase modes make use of the single-shot technique.

An acquired waveform consists of a series of measured voltage values sampled at a uniform rate on the input signal. The acquisition, which consists of a single series of measured data values associated with one trigger event, is typically stopped at a fixed time after the arrival of the event, as determined by the trigger delay. The time of this trigger event is measured using the timebase clock. And the horizontal position of a waveform is determined using the trigger event as the definition of time zero. Waveform display is also carried out using this definition.

Because each channel has its own ADC, the voltage on each input channel is sampled and measured at the same instant. This allows very reliable time measurements between different channels.

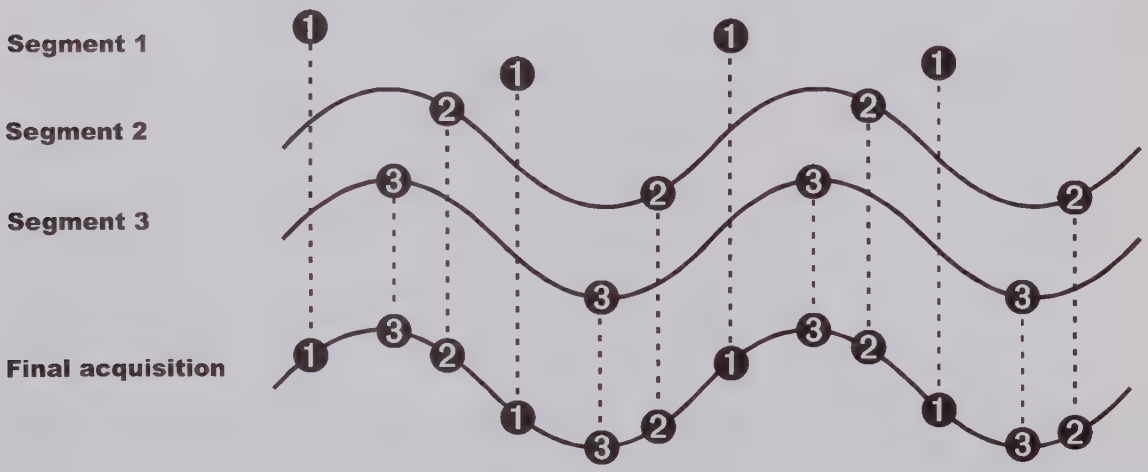
Trigger delay can be selected anywhere within a range that allows the waveform to be sampled from well before the trigger event up to the moment it occurs (100 % pre-trigger), or at the equivalent of 10 000 divisions (at the current time/div) after the trigger.

For fast timebase settings the ADCs' maximum single-shot sampling rate is used (on one and each channel, with higher sampling rates achieved by combining channels). For slower timebases, the sampling rate is decreased and the number of data samples maintained. (*See* Appendix A *for details*).

Peak Detect

When using slow timebases, sample-rate decreases and very short events such as glitches can be missed if they occur between two samples. To prevent this, a special circuitry called the Peak Detect system can be switched on to capture the signal envelope with a resolution of 2.5 ns. This is done without destroying the underlying, simultaneously captured data, on which processing — pulse parameters, FFT, averaging — can be performed.

Random Interleaved Sampling (RIS)



RIS is an acquisition technique that allows effective sampling rates higher than the maximum single-shot sampling rate, and is used on repetitive waveforms with a stable trigger.

The RIS maximum effective sampling rate of 10 GS/s can be achieved by acquiring 20 single-shot acquisitions (also called bins) at 500 MS/s, the bins being positioned approximately 0.1 ns apart. The process of acquiring 20 bins that satisfy this time constraint is random. The relative time between ADC sampling instants and the event trigger provides the necessary variation, measured by the timebase to 10 ps accuracy.

On average, 104 trigger events are needed to complete an acquisition. But sometimes many more are needed. These segments are interleaved to provide a waveform covering a time interval that is a multiple of the maximum single-shot sampling rate. However, the real-time interval over which the waveform data are collected is orders of magnitude longer and depends on the trigger rate and the desired level of interleaving. The oscilloscope is capable of acquiring approximately 40 000 RIS segments per second.

RIS acquisitions do not have to be "complete" in order to be useful. A RIS acquisition can be stopped manually using the STOP button or automatically with the AUTO button. RIS waveforms with missing segments can be treated.

Roll

Single-shot acquisitions at timebase settings slower than 0.5 s/div (10 s/div for traces with more than 50 000 points) have a sufficiently low data rate to allow the display of the incoming points in real time. The oscilloscope shows the incoming data continuously, until a trigger event is detected and the acquisition completed. The latest data is used to update the trace display in the same manner as a strip-chart recorder. Waveform Math and Parameter calculations are done on the completed waveforms.

The behavior of the STOP, SINGLE, NORMAL and AUTO buttons is modified in Roll Mode (*see page 7–9*).

Sequence

Sequence Mode is an alternative to single-shot acquisition that offers many unique features. The complete waveform consists of a number of fixed-size segments acquired in Single-Shot Mode (*see* Appendix A *for the limits*), which are able to be selected.

The dead time between the trigger events for consecutive segments can be kept to under 50 µs — in contrast to the hundreds of milliseconds normally found between consecutive single-shot

waveforms. Complicated sequences of events covering a large time interval can be captured in fine detail, ignoring uninteresting periods between events. And time measurements can be made between events on different segments of a sequence waveform using the full precision of the acquisition timebase.

Trigger-time stamps are given for each of the segments in the "Text & Times Status" menu. Each individual segment can be displayed by Zoom, or used as input to the MATH functions.

Sequence Mode can be used in remote operation to take full advantage of the scope's high data-transmission capability: overlapping transmission of one waveform with its successor's acquisition (*see the* Remote Control Manual *for details*).

The timebase setting in Sequence Mode is used to determine the acquisition duration of each segment, which will be 10 x TIME/DIV.

Timebase setting, desired number of segments, maximum segment length and total available memory are used to determine the actual number of samples/segment and time/point. The display of the complete waveform with all its segments may not entirely fill the screen.

Sequence Mode is normally for acquiring the desired number of segments and terminating the waveform acquisition. It can also be used to acquire the segments continuously, overwriting the oldest ones as needed, with a manual STOP order or timeout condition being used to terminate the waveform acquisition.

The behavior of the STOP, SINGLE, NORMAL, and AUTO buttons is modified in Sequence Mode (*see page 7–9*).

Note: *to ensure low deadtime between segments, button-pushing and knob-turning is to be avoided during sequence acquisition.*

Trigger Capabilities

The two main oscilloscope-trigger groups, used for determining when to stop sampling data are:

- **Edge** Triggers, including
  - Simple threshold triggers (on an input signal)
  - LINE signal triggers
  - Triggers with hold-off by time
  - Triggers with hold-off by number of trigger events
- **SMART** Triggers, including
  - Glitch triggers (on the pulse width of a trigger signal)
  - Interval triggers (on the interval between trigger transitions)
  - Exclusion triggers (on abnormal signals only)
  - TV triggers for composite video signals
  - Dropout triggers for transitions that cease after a time
  - Pattern triggers (on a logical combination of the state of each channel)
  - Qualified triggers, which trigger on one signal after a transition on another, with the possibility of additional requirements.

In order to capture rare phenomena such as glitches, spikes, missing bits and intermittent faults, an oscilloscope must be able to trigger on elusive events. This scope offers a variety of sophisticated trigger modes, based on a counter that can be set by one signal and pre-set to count a specified number of events in another (1 to 10^9). Alternatively, the counter can be set to measure time intervals of up to 20 s.

Edge Trigger

Single Edge triggers are described by source, coupling, slope, and level condition, with the same parameters used for building up SMART triggers.

— **Source** is selected from:

- CH 1, CH 2, CH 3, CH 4: the acquisition channel signal conditioned for the overall voltage gain, coupling, and bandwidth.
- LINE: the line voltage that powers the oscilloscope. It can be used to provide a stable display of signals synchronous with the power line. Coupling and level are not relevant for this selection.
- EXT: the signal applied to the EXT BNC connector. It can be used to trigger the oscilloscope within a range of ± 0.5 V and an input impedance of 1 MΩ and 50 Ω (not applicable if the external clock is selected in the timebase menu).
- EXT/10: the signal applied to the EXT BNC connector. It can be used to trigger the oscilloscope within a range of ± 5 V and an input impedance of 1 MΩ and 50 Ω (not applicable if the external clock is selected in the timebase menu).

— **Coupling** refers to the type of signal coupling at the input of the trigger circuit. Note that the trigger coupling can be independently selected for each of the sources. The DROPOUT and Qualified triggers use these selections. Therefore, a change of trigger source can also result in a change of the shown trigger coupling. The coupling choices are:

- **DC**: All of the signal's frequency components are coupled to the trigger circuit. This Coupling Mode is used in the case of high-frequency bursts, or where the use of AC coupling would shift the effective trigger level.

- **AC**: Signals are capacitively coupled. DC levels are rejected and frequencies below 50 Hz attenuated.
- **LF REJ**: Signals are coupled via a capacitive high-pass filter network. DC is rejected and signal frequencies below 50 kHz attenuated. The LF REJ trigger mode is used when stable triggering on medium- to high-frequency signals is desired.
- **HF REJ**: Signals are DC-coupled to the trigger circuit and a low-pass filter network attenuates frequencies above 50 kHz. The HF REJ trigger mode is used to trigger on low frequencies.
- **HF**: Used for triggering on high-frequency repetitive signals in excess of 300 MHz. Maximum trigger rates greater than 500 MHz are possible. HF triggering should be used only when needed. It will be automatically overridden and set to AC when incompatible with other trigger characteristics, as is the case for SMART triggers. Only one slope is available, indicated by the trigger symbol.

— **Slope** selects the direction of the trigger voltage transition to be used to generate a trigger event. The selected slope is associated with a trigger source in the same way as the coupling.

— **Level** defines the source voltage at which the trigger circuit will generate an event. The selected level is associated with a trigger source in the same way as the coupling. Note that the trigger level is specified in volts and is normally unchanged when the vertical gain or offset is modified.

— **Amplitude** and **Range** of trigger levels are limited as follows:

- ± 5 screen divisions with a channel as trigger source.
- ± 0.5 V with EXT as trigger source.
- ± 5 V with EXT/10 as trigger source.
- None with LINE as trigger source (zero crossing is used).

Edge Trigger with Holdoff

Holdoff is an additional characteristic of the trigger circuitry. Without it, the time between successive trigger events is limited only by the input signal, the coupling, and the oscilloscope's bandwidth.

But sometimes a stable display of complex repetitive waveforms can be achieved by placing a condition on this time. This *holdoff* is expressed either as a time or an event count.

In the first case, the time is measured starting at one trigger event, and the next event arriving after it is allowed to trigger the oscilloscope.

The event count is the number of trigger events to be ignored after one trigger event and until the next one allowed.

The choice of which count is used depends on the application. Either can often obtain the same result.

Note that the holdoff is started by potential triggers and not at the end of an acquisition. Potential triggers will be accepted if the oscilloscope is ready, and ignored if still busy handling the previous trigger event. Holdoff ensures synchronization between successive real triggers.

Timebase and Trigger Controls

STOP

— used to halt the acquisition, in any of the three *re-arming* modes: Auto, Normal and Single.

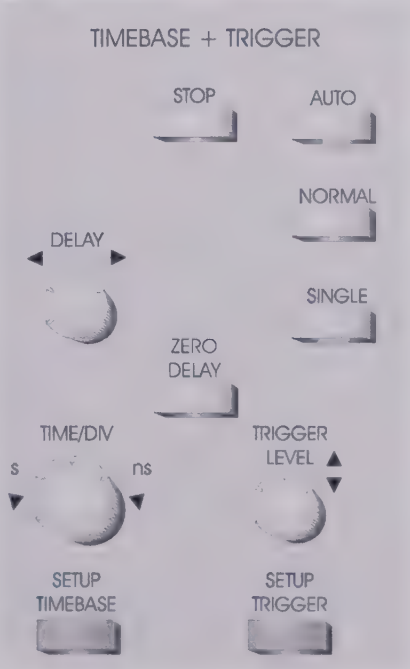
Pressing the STOP button prevents the oscilloscope from acquiring a new signal.

Press STOP while a single-shot acquisition is under way and the last acquired signal will be kept.

Press STOP after an RIS acquisition has been started and the acquisition will be halted and a partial waveform reconstruction will be performed.

Press STOP when the acquisition is in Roll Mode and the incomplete acquisition data will be shown as if a trigger had occurred.

In Sequence Mode, the action will stop the timebase and show all new segments.



AUTO

— places the instrument in Auto Mode: the scope automatically displays the signal if *no* trigger occurs within 60 ms.

If a trigger does occur within this time, the oscilloscope behaves as if in Normal Mode.

Press AUTO in RIS Mode and the acquisition will be terminated and shown each second (some required segments may be missing).

In Roll Mode, the oscilloscope samples the input signals continuously and indefinitely. The acquisition has no trigger condition but can be stopped as desired.

In Sequence Mode, the acquisition will be terminated if the time between two consecutive triggers exceeds a timeout that can be selected (see "UTILITIES" menu under "SPECIAL MODES"). The next acquisition is then started from Segment 1.

NORMAL

— will continuously update the screen as long as a valid trigger is present. If not, the last signal is preserved and the warning "SLOW TRIGGER" is displayed in the Trigger Status Field.

In Roll Mode, the acquisition is terminated when the last needed data after a trigger have been taken. The display pauses to show the entire waveform. It then goes back into Roll Mode while it waits for the next trigger.

In Sequence Mode the acquisition is terminated after the last segment is acquired. The next acquisition is started immediately. Sequence WRAP in Normal is the same as in Single-Shot Mode.

SINGLE

— places the scope in Single-Shot Mode, where it waits for a single trigger to occur, then displays the signal and stops acquiring. If no signal occurs, the button can be pressed again to show the signal being observed without a trigger.

When in RIS Mode the instrument waits for all the trigger events required to build up one signal on screen before it stops. This may require as many as 4000 trigger events.

Roll Mode behavior is the same as Single-Shot but without the need to press the button a second time to show the signal.

— is used to adjust the pre- or post-trigger delay. Pre-trigger adjustment is available from zero to 100 % of the full time-scale in steps of 1 %. The pre-trigger delay is illustrated by the vertical arrow symbol at the bottom of the grid. Post-trigger adjustment is available from 0 to 10 000 divisions in increments of 0.1 of a division. The post-trigger-delay value is labeled in seconds and is located in the on-screen Trigger Delay Field.

— sets the trigger delay at zero, the trigger instant at the left-hand edge of the grid.

— selects the time per division in a 1–2–5 sequence. The time/div setting is displayed in the Acquisition Summary field.

— adjusts the trigger threshold. The amplitude of trigger signals and the range of trigger levels is limited: ± 5 screen divisions with a channel as trigger source; ± 0.5 V with EXT as trigger source; ± 5 V with EXT/10 as trigger source; and Inactive with Line as trigger source. The trigger sensitivity is better than a third-of-a-screen division.

— menu-entry button: calls up the "TIMEBASE" menus, *described in the next chapter*, TIMEBASE Setup.

— menu-entry button: calls up the "TRIGGER SETUP" menus, *detailed in Chapter 9*, Edge and SMART Triggers.

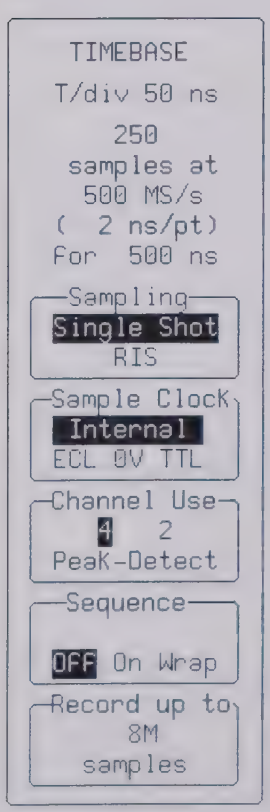
The TIMEBASE Menus

TIMEBASE

SETUP
TIMEBASE

Press to access and choose:

- **Single-Shot or Interleaved (RIS) sampling**
- **External clock**
- **Channel pairing and Peak Detect**
- **Sequence Mode**
- **Number of segments in Sequence Mode**
- **Maximum record length.**



The "TIMEBASE" menus also show the number of points acquired, the sampling rate and the total time span.

Sampling

For selecting these two modes of aquisition:

"**Single Shot**" — displays data collected during successive single-shot acquisitions from the input channels. This mode allows the capture of non-recurring or very low repetition-rate events simultaneously on all input channels. "**RIS**" (Random Interleaved Sampling) — achieves a higher effective sampling rate than Single-Shot, provided the input signal is repetitive and the trigger stable.

Sample Clock

To select "**Internal**" or External ("**ECL**", "**0V**", "**TTL**") clock modes (*see next page*).

Channel Use

To select channel pairing and control Peak Detect Mode.

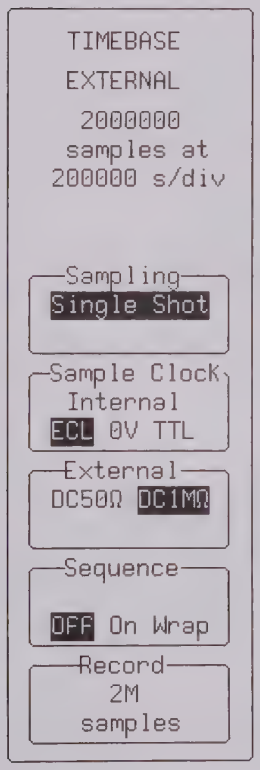
Sequence

For turning "**Off**" or selecting "**Sequence**" or "**Wrap**" Mode.

Record up to

For selecting the maximum number of samples to be acquired, using the associated menu knob.

TIMEBASE EXTERNAL — appears when an External clock mode is chosen. The CKIO option allows clock signals to be supplied at the EXTernal trigger BNC input for driving the scope's ADCs.



Sampling

This menu is inactive when the external sample clock is being used. Only single-shot acquisition is available (*see below*).

Sample Clock

For selecting a description of the signal applied to the EXT BNC connector for the sample clock up to 100 MHz. The rising edge of the signal is used to clock the ADCs of the oscilloscope. The effective thresholds for sampling the input are*:

ECL	–1.3 V
0V	0.0 V
TTL	+1.5 V

RP (Rear Panel) specifies that the 50–500 MHz external clock connected to the rear panel be used as the sample clock (*see* CKTRIG Manual *for details*).

External

To select the input coupling for the external clock signal.

Sequence

Offers Sequence Mode. The corresponding knob is used to adjust the number of segments. Neither the trigger time stamps nor the AUTO sequence time-out feature are available when the external clock is in use. Nor is the inter-segment dead time guaranteed.

Record

To select the desired number of samples for the single-shot acquisition.

---

* External clock modes are available only if the EXT trigger is not the trigger source.

Notes for using External Clock

The time/div is expressed in s/div which is to be thought of as samples/div.

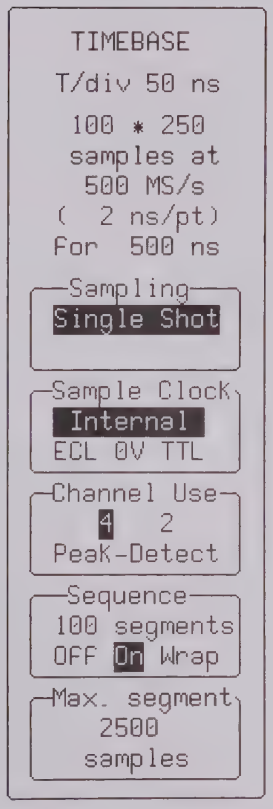
The trigger delay is also expressed in samples and can be adjusted as usual.

No attempt is made to measure the time difference between the trigger and the external clock. Therefore, successive acquisitions of the same signal can appear to jitter on the screen.

The oscilloscope will require a number of pulses (typically 50) before it recognizes the external clock signal. The acquisition is halted only when the trigger conditions have been satisfied and the appropriate number of data points have been accumulated.

Any adjustment to the time/division knob automatically returns the oscilloscope to normal (internal) clock operation.

TIMEBASE — Sequence — for operating in Sequence Mode



Sampling

This menu is inactive when the external sample clock is being used. Only single-shot acquisition is available (*see pages 8–2, 8–3).*

Sample Clock

For selecting a description of the signal applied to the EXT BNC connector for the sample clock (*8–2).*

Channel Use

For combining channels to achieve more memory and a greater sampling rate by interleaving the ADCs in time. When "**4**" is selected, no channels are combined. While with "**2**" selected, two pairs of channels — Channels 1 + 2 and 3 + 4 — are combined.

When channels are paired, Channels 1 and 4 are disabled, and both the maximum sampling rate and maximum record length on Channels 2 and 3 are doubled. On fast timebases it is possible to double again the sampling rate by means of a special adapter placed on Channels 2 and 3. With adapter in place, the oscilloscope interleaves the four ADCs and the acquisition memory to achieve the maximum sampling rate and up to four times the initial record length (*see Appendix A for details*).

Sequence

When either "**On**" or "**Wrap**" are activated, the menu changes to the one shown here. The associated menu knob is used to choose the desired number of segments, here given in example as "100 segments".

Also, when "Sequence" is "**On**":

If the trigger mode is Single — press SINGLE — the oscilloscope fills the segments and stops.

But it will wait until STOP is pressed if there are not enough trigger events to fill the segments.

If the trigger mode is Normal — NORMAL — the oscilloscope fills the segments and then, if more trigger events occur, the acquisition is restarted from Segment 1.

If the trigger mode is Auto — AUTO — and if the time between two consecutive triggers exceeds a time-out that can be selected, the acquisition is restarted from Segment 1. The time-out is selected in "SPECIAL MODES" "UTILITIES".

However, when "**Wrap**" is selected, the segments are filled continuously until the STOP button is pressed. The last *n* segments will be displayed. An alternative way to stop the WRAP sequence is through AUTO mode; if the time between two consecutive triggers exceeds a time-out that can be selected, the acquisition will stop.

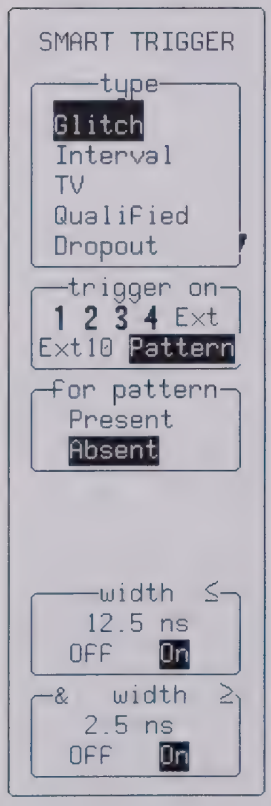
Max. segment

To select using the corresponding button or associated knob the maximum record length for each segment.

***Note:** A summary of the acquisition conditions is displayed above the "TIMEBASE" menus, indicating number of segments, available record length per segment, sampling rate, and timebase setting.*

TRIGGER SETUP

TRIGGER SETUP



Press SETUP TRIGGER to access:

- Edge trigger settings, and
- SMART Trigger™ settings that enable triggering on
  - Glitches
  - Intervals
  - Abnormal signals (Exclusion)
  - TV signals
  - Edge- or State-qualified events
  - Dropouts
  - Patterns.

***Note:** Once specified, Trigger Level (threshold) and Trigger Coupling are the only parameters that pass unchanged from mode to mode for each trigger source.*

***Edge-Trigger Symbols** — illustrated below and on the following page — allow immediate recognition of the current trigger conditions. The more heavily-marked transitions indicate where a trigger will be generated. The symbols are color-matched to the source channel.*

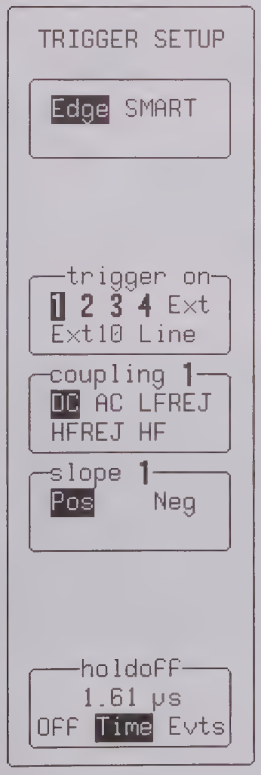
LINE EDGE TRIGGER SYMBOL

Edge Triggers

POSITIVE EDGE TRIGGER SYMBOL

TRIGGER SETUP — Edge — offers selection of:

- **Trigger source**
- **Coupling for each source**
- **Slope (positive or negative), and**
- **Definition of the holdoff in time or events.**



Edge/SMART

To select "**Edge**"

trigger on

For selecting the trigger source in Edge mode.

coupling

To select the trigger coupling for the current source.

slope

To place the trigger point on either the "**Pos**"-itive or "**Neg**"-ative slope of the selected source.

holdoff

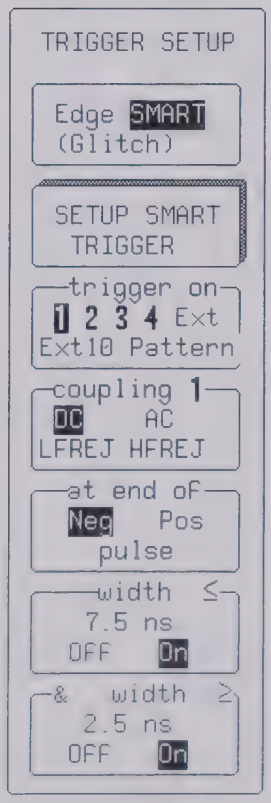
To allow the disabling of the oscilloscope's trigger circuit for a definable period of time or number of events *after* a trigger event occurs. When activated, "holdoff" can be defined as: a period of "**Time**", or a number of events (an event being a change in the input signal that satisfies the trigger conditions).

The menu knob is used to vary the "holdoff" value. Time holdoff values in the range 10 ns–20 s may be entered. Event counts in the range 1–10^9 are allowed.

NEGATIVE EDGE WITH HOLDOFF TRIGGER SYMBOL

SMART Triggers™

TRIGGER SETUP — SMART — accesses the selection of a variety of SMART Triggers™, their menus and associated parameters.



SETUP SMART TRIGGER

Accesses the "SMART TRIGGER" "type" secondary menu from which can be selected the triggers described in this chapter.

The other menus shown on this page remain the same as here even after "SETUP SMART TRIGGER" is selected, and are first described *page 9–5*.

SMART-Trigger Symbols — illustrated on the following pages — ***allow immediate recognition of the current trigger conditions. The more heavily-marked transitions indicate where a trigger will be generated. The symbols are color-matched to the source channel.***

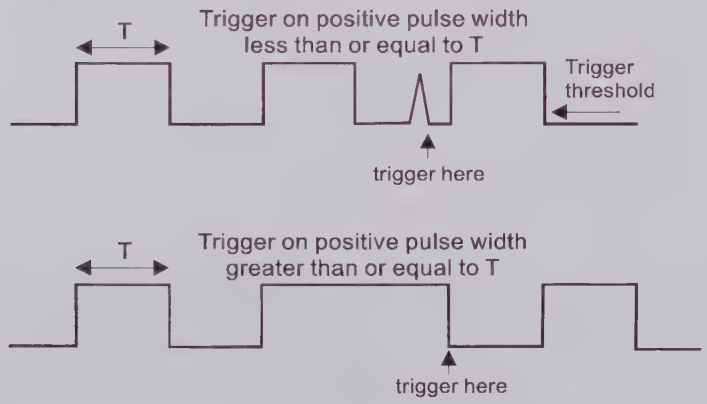
GLITCH Triggers

The GLITCH Trigger tests the pulse-width at the trigger level of the input signal, by triggering on glitches, or fast transitions. Catching elusive rare glitches becomes easy.

In digital electronics, where the circuit being tested normally uses an internal clock, a glitch can theoretically be defined as *any pulse with a width smaller than the clock- or half- period.*

But in the broader sense, a glitch is a pulse *much faster than the waveform under observation.*

The GLITCH Trigger offers a broad range of capabilities for applications in fields as diverse as digital and analog electronic development, ATE, EMI, telecommunications, and magnetic media studies.

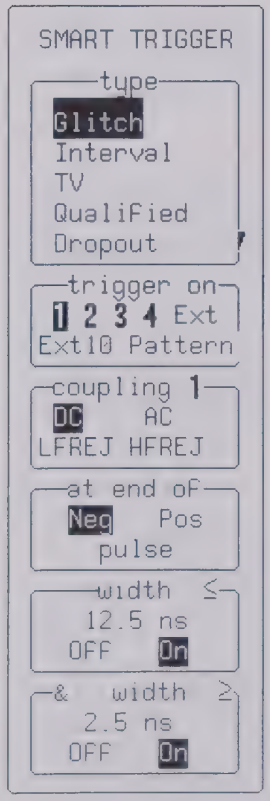


GLITCH TRIGGERS

This trigger generates an event at the end of a pulse that satisfies the desired limits on its width. Both negative and positive pulses can be used. The width limits can be chosen as smaller or greater than a given value, either within or outside a time window.

Widths with a 2.5 ns resolution, starting at a minimum value of 2.5 ns, can be selected. For recurrent glitches, RIS Mode (*see previous chapter*) allows glitch visualization with an equivalent sampling rate of up to 10 GS/s — one sample point every 100 ps.

SMART TRIGGER — Glitch



type

To select "**Glitch**".

GLITCH TRIGGER SYMBOL

trigger on

For selecting the trigger source.

coupling

To select the trigger coupling.

at end of

To define the test on either "**Pos**"-itive or "**Neg**"-ative pulses.

width ≤

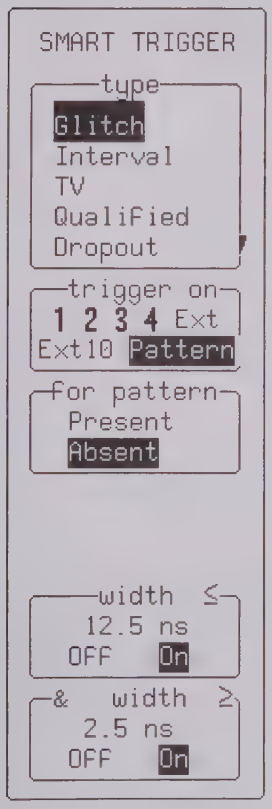
When "**On**" instructs the instrument to trigger if the pulse is smaller than the value defined in this field. The value can be adjusted with the associated menu knob, while the test can be turned on or off by pressing the menu button and can be used in combination with the "width ≥" test. Width values in the range < 2.5 ns to 20 s can be entered.

& width ≥

"**On**" instructs the instrument to trigger if the pulse is greater than the value defined in that field. The value can be adjusted using the associated menu knob, and the test turned on or off with the menu button in combination with the "width ≤" test menu selection. The two width limits are combined to select glitches within ("&") a window if the "width ≤" value is greater than the "width ≥" value. Otherwise, they are combined to select glitches outside of the window ("OR" — *see* Interval Trigger).

This is the principle of the Exclusion Trigger, *described page 9–9.*

SMART TRIGGER — GLITCH — Pattern



When "**Pattern**" is selected in GLITCH mode, the instrument triggers on the logic AND of up to five sources (*see page 9–18*).

trigger on

To select "**Pattern**".

for pattern

For selecting pattern "**Present**" or "**Absent**".

width ≤

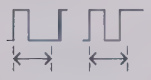
To trigger if the pattern is present or absent for less than the time value defined in that field. The value can be adjusted with the associated menu knob and the test commuted to "≥" by pressing the corresponding menu button.

& width ≥

To trigger if the pattern is present or absent for more than the time value defined in that field. The value can be adjusted and the test commuted to "≤ " as per "width ≤ ".

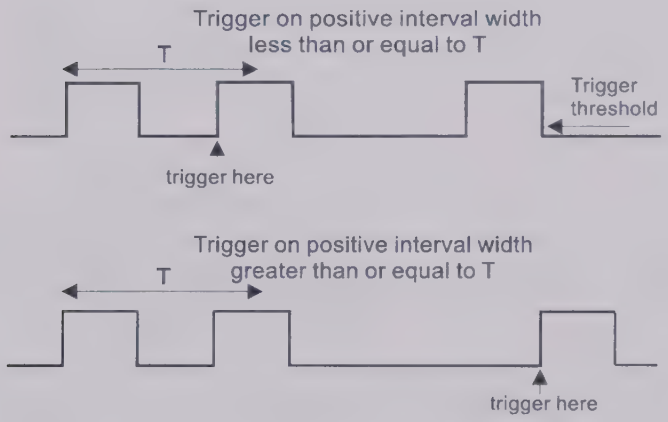
GLITCH TRIGGER WITH TIME WINDOW SYMBOL

Interval Triggers



INTERVAL TRIGGER SYMBOL

Interval Trigger is similar to GLITCH trigger but for the test, which is performed over the width of an interval rather than that of a pulse. For ranging applications, the Interval Trigger can be used to ignore unwanted signal reflections.

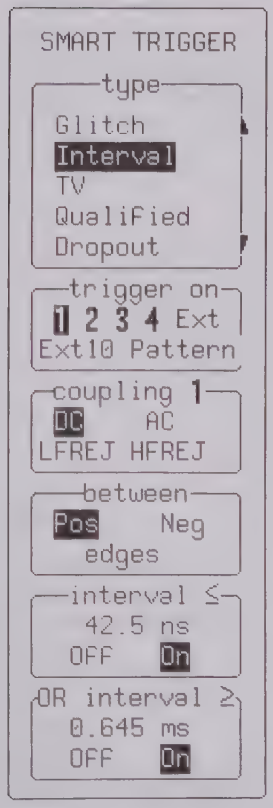


INTERVALTRIGGERS

The trigger generates an event if the interval between two similar trigger signal transitions satisfies the desired limits. Unlike the GLITCH trigger, its lower time limit is 10 ns.

Missing bits in long data streams are easily triggered-on using this interval-width triggering.

SMART TRIGGER — Interval



type

To select "**Interval**".

trigger on

For selecting the trigger source.

coupling

For selecting the trigger coupling.

between

To define the interval between two adjacent "**Pos**"-itive or "**Neg**" -ative edges.

interval ≤

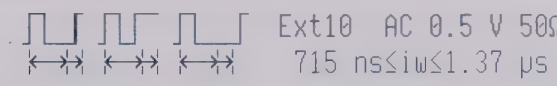
To trigger if the interval is smaller than the value defined here, which can be adjusted using the associated knob. The test can be turned on or off with the corresponding menu button, and can be used in combination with the "interval ≥" test. Interval values in the range 10 ns to 20 s may be entered.

OR interval ≥

To trigger if the interval is greater than the value defined here, which can be adjusted using the associated menu knob The test can be turned on or off using the corresponding menu button, and can be used in combination with the "interval ≤" test. The two interval limits are combined to select intervals within ("&") a window if the "interval ≤" value is greater than the "interval ≥" value. Otherwise they are combined to select intervals outside of ("OR") the window. This is the principle of the Exclusion Trigger, *described next page.*

INTERVAL TRIGGER WITH TIME WINDOW SYMBOL

Exclusion Triggers



EXCLUSION TRIGGER SYMBOL

Both Glitch and Interval triggers can be used as Exclusion triggers. The Exclusion trigger allows the normal width or period of signals to be specified, with the scope instructed to ignore the normally shaped signals and trigger only on abnormal ones. Circuit failures can be looked for all the time.

For example, the trigger window could be set up to eliminate pulses with a width of between 47.5 and 50 ns. Only waveforms with pulse widths that do *not* fall within this range would trigger the oscilloscope, with all undesirable signal behavior captured and displayed. Such waveforms can be viewed individually, or overlaid and printed. Waveform math and processing, including FFTs, can also be performed.

See Capturing Rare Phenomena, *in the* Hands-On Guide *for practical tips on using the Exclusion Trigger.*

TV Trigger

TV trigger allows stable triggering on standard or user-defined composite video signals, on a specific line of a given field. Applications can be found wherever TV signals are present.

This is a special kind of Edge-Qualified trigger (*page 9–12*). A composite video signal on the trigger input is analyzed to provide a signal for the beginning of the chosen field — *any*, *odd*, or *even* — and for a signal at the beginning of each line.

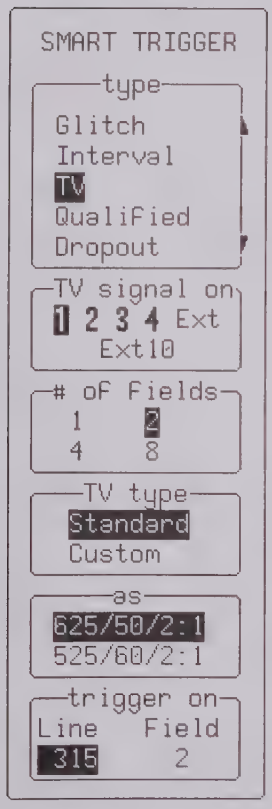
The field signal provides the starting transition and the beginning of line pulses are counted to allow the final trigger on the chosen line.

The TV trigger includes an enhanced field-counting capability, FIELDLOCK (*9–11*), which maintains the trigger on a known field relative to an initial trigger.

Each field, the number of fields, the field rate, interlace factor, and number of lines per picture must be specified — although there are standard settings for the most common types of TV signals.

The TV trigger can also function in a simple any-line mode.

SMART TRIGGER — TV



type

To select "**TV**" .

TV signal on

For selecting the trigger source.

# of fields

To define the number of fields — up to eight.

TV type

For selecting either "**Standard**" or "**Custom**" TV decoding.

as

For choosing "**Standard**", when a selection of between 625/50/2:1 or 525/60/2:1 standard is made. Or "**Custom**", when the number of lines, number of cycles, and interlacing factor for non-standard TV signals is set.

trigger on

For selecting the line and field number on which to trigger.

1 Line 283(20) Field 2,
525/60/2:1

TV TRIGGER SYMBOL (NTSC)

Notes for TV Trigger

A. Because most TV systems have more than two fields the enhanced field-counting capability (FIELDLOCK) allows the oscilloscope to trigger consistently on a chosen line within a chosen field of the signal. The field- numbering system is relative, in that the oscilloscope cannot distinguish between lines 1, 3, 5, and 7 (or 2, 4, 6, and 8) in an absolute way.

B. For each of the characteristics the following remarks apply:

1) 625/50/2:1 (European style PAL and SECAM systems)

This setting should be used for most of the standard 50 field/s signals. The lines may be selected in the range 1 to 626 where line 626 is identical to line 1.

Number of fields: eight should be very useful for color PAL signals; four is appropriate for SECAM signals.

2) 525/60/2:1 (American style NTSC systems)

This setting should be used for standard 60 field/s NTSC signals. The lines can be selected in the range 1 to 1051, where line 1051 is identical to line 1.

Number of fields = 4 should be very useful for American-style NTSC systems.

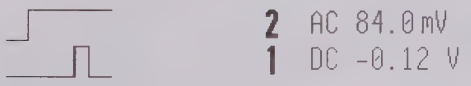
3)?/50/?, ?/60/?

In order to allow maximum flexibility, no line-counting convention is used. The line count should be thought of as a line-synchronizing pulse count, and it includes the transitions of the equalizing pulses. For certain extreme cases of TV signals, the field transition recognition will no longer work. In this case, only the "any line" mode will be available.

C. The enhanced field-counting capability cannot be used for RIS acquisitions.

D. Composite video signals must have negative-going synch to be decoded correctly.

Qualified Triggers



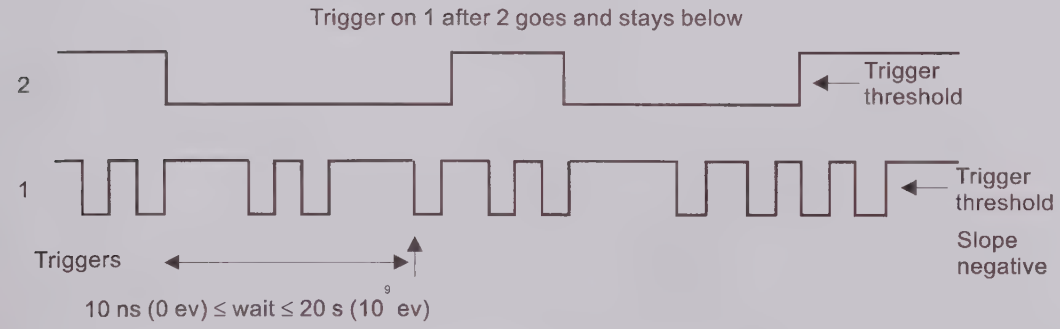
STATE-QUALIFIED TRIGGER SYMBOL

The transition of a signal above or below a given level — the validation — serves as an enabling, or qualifying, condition for a second signal that is the source of the trigger. Typical applications can be found wherever time violations occur — in micro-processor debugging or telecommunications, for example.

There are two types of Qualified Trigger: **State-Qualified**, where the amplitude of the first signal must remain in the desired state until the trigger occurs; and **Edge-Qualified**, where the validation is sufficient and there is no additional requirement placed on the first signal.

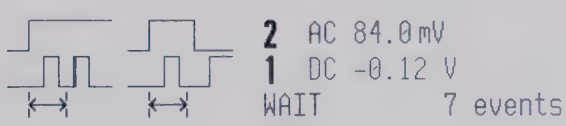
The trigger can occur immediately after the validation, or within a particular time limit after it, or following a predetermined time delay or count of potential trigger events. The time delay or trigger count is restarted at every validation.

State Qualified — the qualifier signal is valid when it *goes and stays* above or below a defined threshold. A trigger is accepted while the qualifier is valid, before or after a given time or given number of events. When the qualifier ceases to be valid, the time- and event-counters are reset.

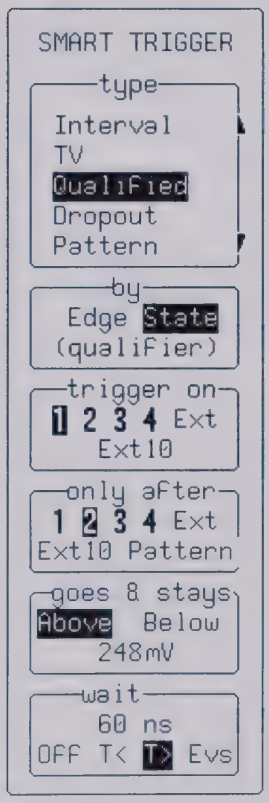


STATE-QUALIFIED TRIGGERS

SMART TRIGGER — Qualified — State



STATE-QUALIFIED TRIGGER WITH EVENT WAIT SYMBOL



type

To select "**Qualified**".

by

To select "**State**".

trigger on

For selecting the trigger source — the other conditions for this source can be set up using an Edge trigger.

only after

To select the qualifier source — the other conditions can be set up using Edge.

goes & stays

For selecting the qualifier threshold using the associated knob, and using the menu button to select whether the qualifier signal will be valid either "**Above**" or "**Below**" that threshold.

When "**Pattern**" is selected as the qualifier source, this menu is used to determine whether the pattern should be *present* or *absent* (*see page 8–1 for Pattern Trigger*).

wait/within

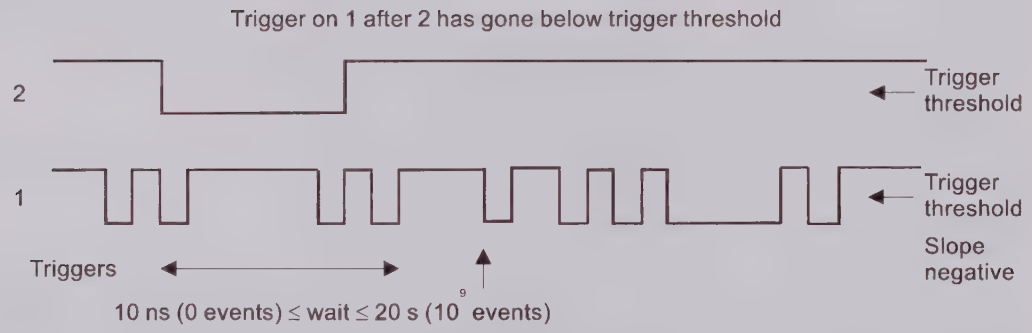
To specify the time limit ("**T<**") for accepting the trigger event. And alternatively, to specify how much time ("**T>**") or how many trigger events ("**Evs**") should be allowed before the acquisition is taken on the next trigger event.

The qualifier signal must remain valid until the final trigger has been received.

The time value can be chosen in the range 10 ns–20 s.

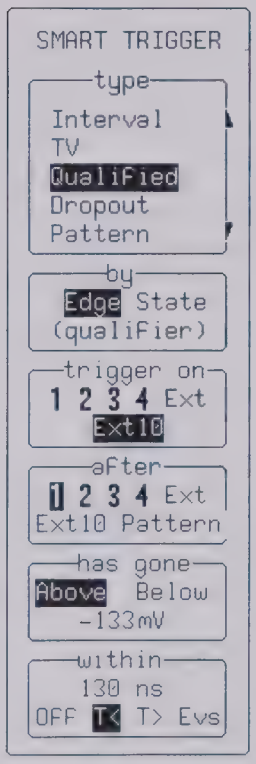
The trigger event count can be chosen in the range 1–10^9.

Edge-Qualified Trigger — the qualifier signal is valid as soon as it "has gone" above or below a defined threshold (the valid transition). A trigger is accepted within or after a given time, or after a certain number of trigger events. But as soon as a new valid transition occurs, the time- and event-counters are reset.



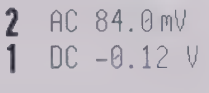
EDGE QUALIFIED TRIGGERS

SMART TRIGGER — Qualified — Edge



type

To select "**Qualified**".



EDGE-QUALIFIED TRIGGER SYMBOL

by

To select "**Edge**".

trigger on

For selecting the trigger source — the other conditions for this source are set up using an Edge trigger.

after

For selecting the qualifier source — other setup conditions use Edge.

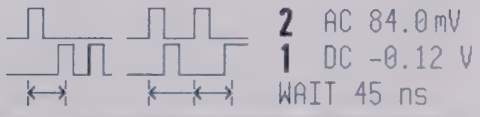
has gone

To adjust the qualifier threshold and determine whether the qualifier signal is valid once it "has gone" above or below that threshold.

"**Pattern**" selected as the qualifier source determines whether the pattern should be *present* or *absent* (*see 9–1.*)

wait/within

To specify the time limit ("**T<**") for accepting the trigger event. Or, to specify the delay in time ("**T>**") or number of trigger events ("**Evs**") after a valid transition has occurred. A trigger can only be accepted after this delay. Any subsequent qualifier event restarts this count. The time value can be chosen in the range 10 ns–20 s. The trigger event count can be chosen in the range 1–10^9.

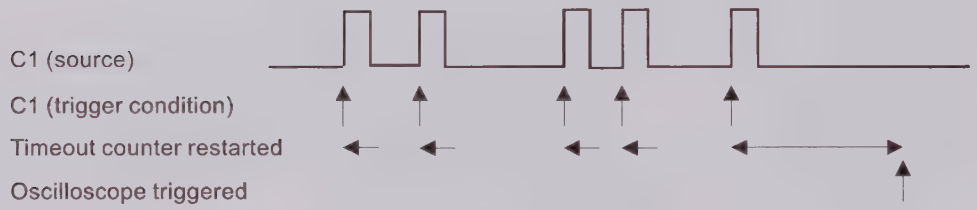


EDGE-QUALIFIED TRIGGER WITH EVENT WAIT SYMBOL

Dropout Triggers

The Dropout Trigger is generated at the end of the timeout period, following the 'last' trigger source transition and when Edge-like signal transitions cease on the trigger source for the timeout value selected.

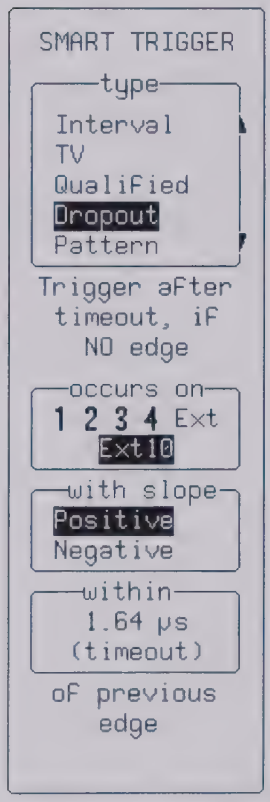
A typical application is on the last 'normal' interval of a signal that has disappeared completely — essentially a single-shot application, and usually with a pre-trigger delay. A RIS acquisition is not useful here because the timing of the trigger timeout is insufficiently correlated with the input channel signals.



DROPOUT TRIGGER

SMART TRIGGER — Dropout

DROPOUT TRIGGER SYMBOL



type

To select "**Dropout**".

trigger after timeout, if NO edge occurs on

For selecting the trigger source.

with slope

To define whether the measurement starts on a "**Positive**" or "**Negative**" slope of the trigger signal.

within

For defining the time-out value in the range 25 ns–20 s.

Pattern Triggers

A Pattern Trigger is a logical 'AND' combination of the states of Channels 1, 2, 3, 4 and EXT. These states are defined as being either low (*L*), high (*H*) or don't care (*X*) for defined trigger thresholds. In addition, the user decides whether the trigger takes place at the beginning or end of the defined pattern — either on *entering* or *exiting* the pattern.

The Pattern Trigger is useful wherever complex logic needs testing. Application fields include computer or microprocessor debugging, high energy physics, in situations where physical events are identified by several events occurring simultaneously, and in telecommunications for the debugging of data transmission buses.

Set to Pattern Trigger, the oscilloscope always checks the logic 'AND' of the defined input logic states.

However, with the help of de Morgan's laws, the pattern becomes far more generalized. Consider the important example of the Bi-level or Window Pattern Trigger.

Bi-level implies the expectation of a single-shot signal on which the amplitude will go in either direction outside a known range.

To set up a Bi-level Pattern trigger, connect the signal to two inputs: Channels 1 and 2 or any other pair that can be triggered on. For example, the threshold of Channel 1 could be set to +100 mV and that of Channel 2 at –200 mV. The Bi-level Trigger will occur if the oscilloscope triggers on Channel 1 for any pulse greater than +100 mV, or on Channel 2 for any pulse less than –200 mV. For improved precision, the gains of the two channels should be at the same setting.

In Boolean notation we can write:

$$\text{Trigger} = \text{CH 1} + \overline{\text{CH 2}},$$

i.e. trigger when entering the pattern

CH 1 = high OR CH 2 = low.

By de Morgan's laws this is equivalent to:

$$\text{Trigger} = \overline{\overline{CH\ 1} \cdot CH\ 2}$$

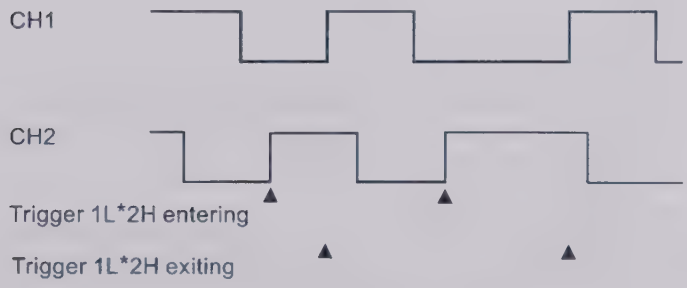
i.e. trigger when exiting the pattern

CH 1 = low AND CH 2 = high.

This configuration can be easily programmed.

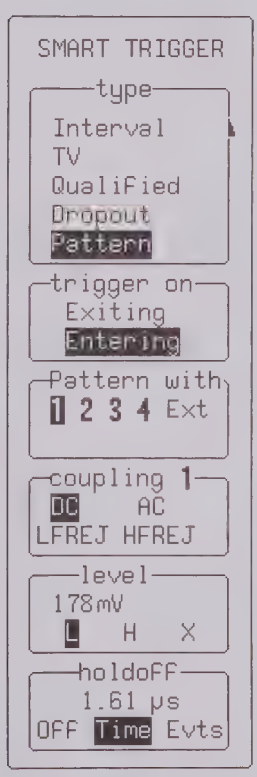
The possibility of setting the threshold individually for each channel extends this method so that it becomes a more general Window Trigger: in order to trigger the input pulse amplitude must lie within or outside a given arbitrary window.

Pattern Trigger has been designed to allow a choice of the trigger point. By choosing *1L*2H entering*, the trigger will be given at the moment the pattern 1L*2H becomes true.



PATTERN TRIGGER TIMING

SMART TRIGGER — Pattern



Enter 1L∗2H∗3H∗4H∗EL

PATTERN TRIGGER SYMBOL

type

To select "**Pattern**".

trigger on

To select "**Entering**" for the scope to trigger when the pattern starts being *true*, and "**Exiting**" for triggering when it stops being *true*.

Pattern with

For selecting the channel to be modified using the lower menus' corresponding menu buttons.

coupling

To select the desired coupling.

Note: HF coupling is not available for Pattern trigger.

level

For modifying these values using the associated knob — adjusts the level — and the corresponding menu button, which chooses "**L**" (low), "**H**" (high), or "**X**" (Don't care).

holdoff

To disable the trigger circuit for a definable period of time or number of events *after* a trigger event (a change in the input signal that satisfies the trigger conditions).

When not turned off, holdoff can be defined as:

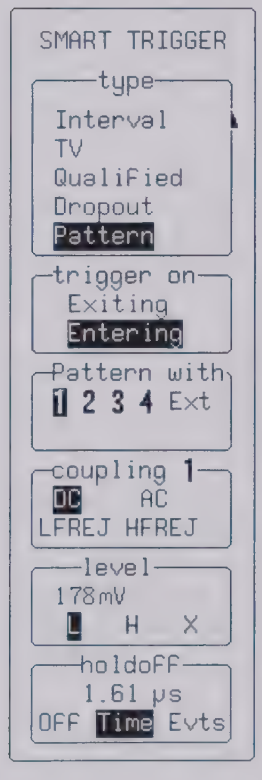
- a period of "**Time**"
- a number of "**Evts**" — events.

Use the associated menu knob to vary the "holdoff" value.

Time holdoff values in the range 10 ns–20 s may be entered.

Event counts in the range 1–10^9 are allowed.

SMART TRIGGER — Pattern



type

To select "**Pattern**".

trigger on

To select "**Entering**" for the scope to trigger when the pattern starts being *true*, and "**Exiting**" for triggering when it stops being *true*.

Pattern with

For selecting the channel to be modified using the lower menus' corresponding menu buttons.

coupling

To select the desired coupling.

Note: HF coupling is not available for Pattern trigger.

level

For modifying these values using the associated knob — adjusts the level — and the corresponding menu button, which chooses "**L**" (low), "**H**" (high), or "**X**" (Don't care).

holdoff

To disable the trigger circuit for a definable period of time or number of events *after* a trigger event (a change in the input signal that satisfies the trigger conditions).

When not turned off, holdoff can be defined as:

- a period of "**Time**"
- a number of "**Evts**" — events.

Use the associated menu knob to vary the "holdoff" value.

Time holdoff values in the range 10 ns–20 s may be entered.

Event counts in the range 1–10^9 are allowed.

Zoom and Math Functions

A wide range of ZOOM + MATH processing functions can be performed on acquired waveforms, described here. ***(See page 10–4 for a description of their controls and*** **Chapter 11** ***for Math Setup menus.)***

ZOOM

Four processed traces are available for straight-forward zooming or waveform mathematics. Any one of these traces — A, B, C or D — can be set up to zoom a trace acquired on Channel 1, 2, 3 or 4, stored on any of the four reference memories M1–4, or any of the other three original traces. Thus Trace A, for example, could be set up to zoom Trace B, C, or D, but not itself. The Displayed Trace label at left of screen indicates the source.

The four ZOOM + MATH knobs (*see page 10–4)* adjust the horizontal and vertical positions and expansion factors of the zoomed trace. Only one trace can be adjusted at a time, so when several traces are displayed the controls are assigned to the one trace with the SELECT ABCD button.

Precise Timing Measurements with Zooming

Several traces can be zoomed from the one waveform for precise timing measurements. For example, for a waveform composed of two pulses separated by a long delay, Trace A could be made the zoom of the first pulse, while Trace B zoomed the second.

Even with 8 million points acquired, zooming can be done up to where there are only a few points on the screen. The time resolution on the viewed trace can thus be immensely improved.

With 25 000 points per channel, on a timebase of 0.1 ms/div, for example, traces can be expanded to as much as 0.1 µs/div — a factor of 1000. Using Relative Time cursors, a delay of, say, 500 µs could be measured with resolution as high as 0.5 ns.

The combination of long memory and zoom allows extremely accurate time interval measurements.

Multi-Zoom

The zoomed, or intensified, region can be moved simultaneously along two or more different traces, or two or more regions of the same trace. When "Multi-Zoom" "**On**" is selected from the "ZOOM – MATH" menu, the horizontal zoom and position controls apply simultaneously to all displayed traces — A, B, C and D — allowing similar sections of different traces to be viewed at the same time. The vertical controls still act individually on the traces, and switching from one trace to another is done using the TRACE ON/OFF buttons. The highlighting of trace titles in the Displayed Trace label indicates an active Multi-Zoom.

Viewing Reference Memories

The reference memories M1–4 cannot be displayed directly, and must be viewed through A, B, C or D. "MATH SETUP" is used to define the trace as a zoom on the desired reference memory. A shortcut that can be selected from the "RECALL WAVEFORM" menu makes possible the 'recall' of a reference waveform into either A, B, C or D. Whenever this is done, the destination trace is redefined as a zoom of the reference memory, the trace display is switched on, and the previous destination trace definition is lost.

Waveform Mathematics

Any trace A, B, C or D can be set up as a mathematical function — waveform negation, identity, addition, subtraction, multiplication and division, summed averaging of up to 1000 waveforms and the (sin x)/x interpolation function, are all standard.

In addition, waveform processing offers:

- Continuous Averaging
- Summed Averaging of up to 1 000 000 waveforms
- Enhanced Resolution by up to 3 bits with filtering
- Extrema (envelope of many waveforms)
- Mathematical Functions such as Integral, Derivative, Logarithm, Exponential, Square, and Square Root
- Fast Fourier Transform, including FFT averaging
- Parameter Analysis, histogramming and statistical analysis.*

* WP03 Parameter Analysis Package — optional, according to model.

Waveform mathematics can be applied to any channel or reference memory. They can be applied to the four traces, too, allowing several computations to be made in sequence. For example: Trace A could be set up as the difference between Channels 1 and 2; Trace B defined as the average of A, and Trace C made the integral of B — thus displaying the integral of the averaged difference between Channels 1 and 2.

In order to avoid slowing down the instrument with unwanted computations, a mathematical function is only computed when its display is turned on. However, using the same example, it would be sufficient to display Trace C alone, as the instrument knows it must compute A and B as intermediate steps to C.

A processing title for each displayed trace will be shown in the Displayed Trace Label. If the title is missing, the desired processing cannot be done and the contents of the trace remain unchanged.

Zoom of Math Functions

When Trace A, B, C or D is defined as a mathematical function rather than as a simple zoom, the zoom controls remain operative and defining another trace as a zoom of this function is unnecessary. In order to view the entire mathematical function, cancel any expansion or position change by pressing the button RESET.

Speed-Up of Waveform Mathematics

Waveform processing can take time when many data points are involved. But this time period can be reduced by limiting the number of data points used in the computation. The instrument will process the entire waveform by taking every Nth point, where: N depends on the timebase and the desired maximum number of points, and the first point taken is always the data value at the left-hand edge of the screen.

What Happens When Channels are Combined?

Zoom and math functions on Traces A, B, C, D and Reference Memories M1, M2, M3, M4 use the instrument's system memory, which is dynamically allocated to each trace as required.

When more acquisition memory is achieved by combining two or four channels, a single long trace can 'eat up' all the reference memory or zoom and math trace capacity in the instrument. When this happens, an on-screen warning message will avert accidental storing of a new trace to a reference memory already in use.

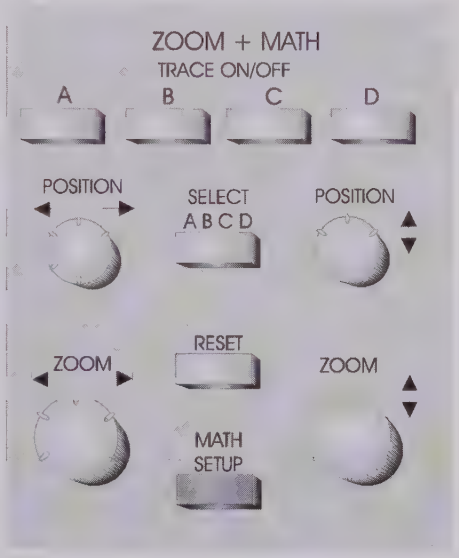
Zoom and Math Controls

The TRACE ON/OFF buttons display the corresponding trace: A, B, C or D. When a trace is switched on, the POSITION and ZOOM knobs, and the RESET button will then be attributed to this, the *active* trace.

— if more than one trace is displayed, pressing this button activates the next in sequence A–D.

— repositions zoomed traces *horizontally*. If the source of the expanded waveform is displayed, an intensified region corresponding to the area of expansion is shown.

— *vertically* repositions the active trace.



— *horizontally* expands or contracts the active trace. If the source of the zoomed trace is also displayed, it will show an intensified region corresponding to the area of expansion.

— *vertically* expands or contracts the active trace.

— resets vertical and horizontal POSITION and ZOOM.

— menu-entry button that accesses the zoom, math and sequence segment features. *See next chapter for details.*

Math SETUP Menus

ZOOM + MATH

Press

to access:

- **Zoom (source) definition, including for vertical, horizontal and Multi-Zoom**
- **Math features such as Arithmetic, Average, Enhanced Resolution, Extrema, Fast Fourier Transform (FFT), and various functions such as integral, exponential and square root**
- **Sequence segment for display.**

Using Math

Traces A, B, C and D can be configured to execute any zoom or math function, and can be chained. For example: Trace A could be configured to average CH 1, Trace B could be made a Fourier Transform (FFT) of A, and Trace C could be made a zoom of B.

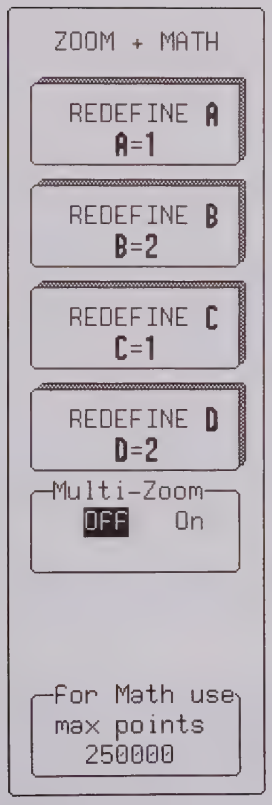
All traces can be viewed simultaneously on-screen using the ZOOM + MATH TRACE ON/OFF buttons. Any function can be zoomed directly.

Waveform Processing Features

The scope's waveform processing features include: Summed Averaging up to one million sweeps, Add, Subtract, Multiply, Divide, Negate and Identity Arithmetic functions, and (sin x)/x Interpolation, Continuous Averaging up to 1024 sweeps, Reciprocate, Rescale, Absolute Value, Derivative, Integral, Logarithm (e), Logarithm (10), Exponential (e), Exponential (10), Square and Square Root. And **Enhanced Resolution offering digital filtering that gives 0.5- to 3-bit** vertical resolution improvement.

Also provided is Frequency Domain Analysis — FFT and FFT Power Averaging — and Rescale in both time and frequency domains.

Other parameter analysis packages, optional or standard according to model, include Histogramming and Statistical Analysis firmware, and Parameter Trending.



REDEFINE A, B, C, or D

To select the trace to be redefined and accesses the "SETUP" menus (*described in the remainder of this chapter).*

Multi-Zoom

For switching Multi-Zoom "On" or "Off". When "**On**", all displayed traces (A,B,C,D) are simultaneously controlled by the horizontal POSITION and ZOOM knobs. When "**OFF**", only the active trace, chosen using the SELECT ABCD button, is controlled by POSITION and ZOOM.

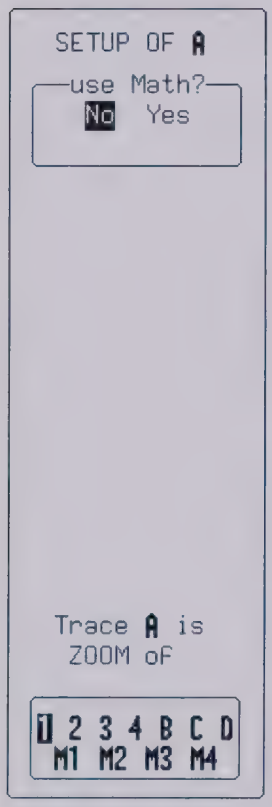
Selected (*not shown*)

When a trace with a zoom of a sequence-mode waveform is selected, the "Selected" menu — not shown here — becomes accessible. Pressing the corresponding menu button toggles the selection between display of a single, specific "Segment" and "All Segments". With the former selected, the associated knob can be used to step through the segments and choose one.

for Math use max points...

For selecting the maximum number of points for all math operations — a low number increases computation speed.

SETUP — Zoom



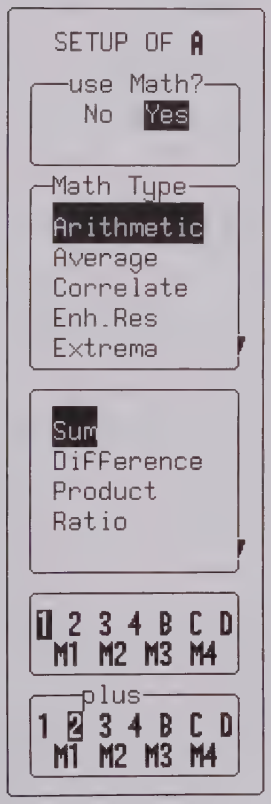
use Math?

For toggling between "**No**" (ZOOM only) and "**Yes**" (ZOOM + MATH) SETUP.

Trace A, B, C or D is ZOOM of

To select the source trace to be zoomed.

SETUP — Arithmetic



— allows addition, subtraction, multiplication and division, as well as choice of the two operands and the operator. The example on this page shows a setup of trace A as the sum of Channels 1 and 2.

use Math?

To select "**Yes**".

Math Type

To select "**Arithmetic**".

Sum Difference Product Ratio

For selecting the operator.

1 2 3 4 B C D
M1 M2 M3 M4

To select one of two operand source traces.

1 2 3 4 B C D
M1 M2 M3 M4

To select the other operand source trace.

Summed Averaging

This is the repeated addition, with *equal* weight, of successive source waveform records. If a stable trigger is available, the resulting average has a random noise component lower than that of a single-shot record.

Whenever the maximum number of sweeps is reached, the averaging process stops. An even larger number can be accumulated simply by changing the number in the "SETUP" "for" menu. However, the other parameters must be left unchanged or a new averaging calculation will be started.

The process may be interrupted by changing the trigger mode from NORMAL to STOP or by turning off the active trace using the respective buttons. Averaging will be resumed when the inverse is done. The accumulated average is reset by pushing the CLEAR SWEEPS button or changing an acquisition parameter such as input gain, offset, coupling, trigger condition, timebase or bandwidth limit. The number of current averaged waveforms of the function or its expansion is shown in the Displayed Trace field.

When summed averaging is selected, the display is updated at a reduced rate — about once every 1.5 s — in order to increase the averaging speed (points and events per second).

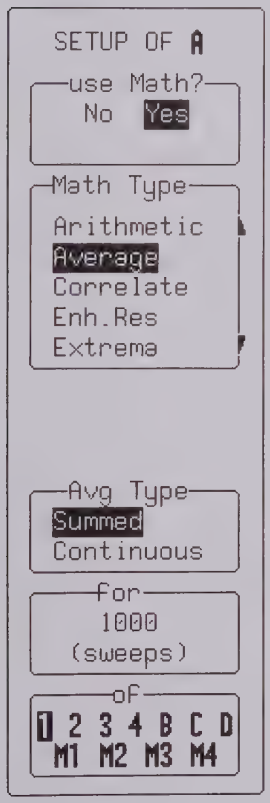
Summed averaging can also be done on sequence waveforms to give the average of the segments. And it can be applied to an expansion of a sequence segment, giving the segment's average waveform over many sequence acquisitions.

Continuous Averaging

This is the repeated addition, with *unequal* weight, of successive source waveforms. It is particularly useful for reducing noise on signals that drift very slowly in time or amplitude. However, the statistics of a continuous average tend to be worse than those from a summed average on the same number of sweeps, as the most recently acquired waveform has more weight than all previously acquired ones. The continuous average is dominated by the statistical fluctuations of the most recently acquired waveforms.

The weight of 'old' waveforms in the continuous average gradually tends to zero (following an exponential rule) at a rate that decreases as the weight increases.

SETUP — Average



— offers Summed (Linear) or Continuous (Exponential) Averaging. Shown here is an example setup of trace A as a Summed Average — over 1000 sweeps — of Channel 1.

Use Math?

To select "**Yes**".

Math Type

To select, in this case, "**Average**" (*other choices in the example menu shown here include options not available on the standard scope*).

Avg Type

To select "**Summed**" or "**Continuous Average**".

for / weight

When "**Summed**" is selected, this menu ("for") is used to define the number of sweeps. When "**Continuous Average**" is chosen, the same menu becomes "weight" and is used to define the weight, similar to number of sweeps.

In "for" the *first* n sweeps will be taken into account, whereas in "weight" the *last* sweep will be given a weight of 1 and the previous result a weight of n in calculating the new average.

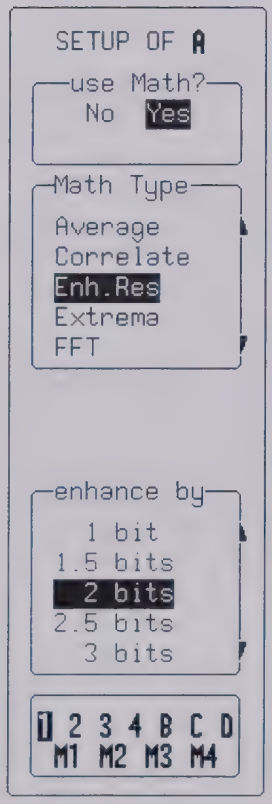
of

For selecting the source trace for averaging.

SETUP — Enhanced Resolution

— allows the selection of low-pass digital filters that increase the resolution of the displayed signal at the expense of its bandwidth. Appendix B gives a detailed explanation.

Note: These digital filters work very much like analog bandwidth-limit ones. In Single-Shot mode, they and the sampling speed affect bandwidth. If high bandwidth is needed at slow timebases, averaging and repetitive sampling should be considered.



use Math?

For selecting "**Yes**".

Math Type

To select "**Enhanced Resolution**".

enhance by

For selecting the filter that will enhance resolution of the displayed signal from one to three bits in 0.5-bit steps.

1 2 3 4 B C D
M1 M2 M3 M4

To select the source trace for filtering.

Extrema Waveforms

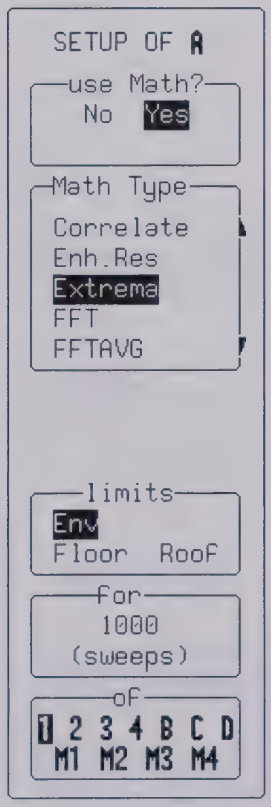
These are computed by a repeated comparison of successive source waveform records with the already-accumulated extrema waveform, which consists of a maxima (roof) and a minima (floor) record. Whenever a given data point of the new waveform is greater than the corresponding maximum roof-record value, or lesser than the corresponding floor value, it replaces it. Thus the maximum and the minimum envelope of all waveform records is accumulated.

Roof and Floor records can be displayed either individually or together.

Whenever the selected maximum number of sweeps is reached, the accumulation process stops. This process may be interrupted by turning the trigger mode from NORM to STOP or the function trace OFF. Accumulation will continue when these actions are reversed. The currently accumulated extrema waveform may be reset by either pushing the CLEAR SWEEPS button or by changing an acquisition parameter such as input gain, offset, coupling, trigger condition, or timebase or bandwidth limit. The number of currently accumulated waveforms is displayed in the Displayed Trace field of the function or that of its expansion.

Whenever the maximum number of sweeps is reached, an even larger number can be accumulated simply by changing the number in "SETUP" "for" menu. However, the other parameters must be left unchanged or the extrema calculation will be restarted.

SETUP — Extrema — used for acquiring a trace envelope over many acquisitions.



use Math?

For selecting "**Yes**".

Math Type

To select "**Extrema**".

limits

To select either "**Envelope**", "**Floor**" or "**Roof**". Floor shows only the lower, and Roof only the upper part of the envelope. Changing the limits does not force the analysis to start again.

for

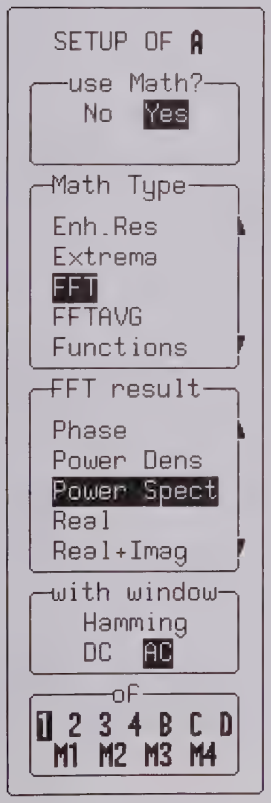
For selecting the number of sweeps.

of

To select the source trace.

SETUP — FFT

— used to display the Fast Fourier Transform (FFT) of a signal and visualize it in the frequency domain. *See* Appendix C: FFT *for more*.



use Math?

To select "**Yes**".

Math Type

For selecting "**FFT**".

FFT result

To select the FFT's output format: "**Imaginary**", "**Magnitude**", "**Phase**", "**Power Dens**"-ity, "**Power Spect**"-rum, "**Real**" or "**Real + Imag**".

with window

Using the corresponding menu button to select the FFT window type from "**Rectangular**", "**Hanning**", "**Hamming**", "**Blackman-Harris**", and "**Flat-top**". And the associated knob to select "**AC**" or "**DC**".

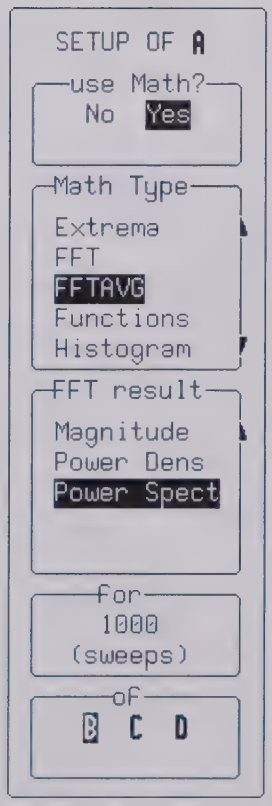
of

For selecting the source trace.

FFT Interruption (Abort): *During FFT computation the FFT sign is displayed in the lower right-hand corner of the screen. The computation of FFT on long time-domain records can take time. The computation can be interrupted at any time using any front-panel control.*

SETUP — FFT Average — used for displaying the FFT power averaging of an FFT source trace, power averaging being useful for characterizing broadband noise or periodic signals without a stable trigger signal. Total power — signal and noise — is measured at each frequency.

Note: The source trace must be an FFT function.



use Math?

For selecting "**Yes**".

Math Type

To select "**FFT AVG**".

FFT result

To select the output format of the FFT Average: "**Magnitude**", "**Power Density**", "**Power Spectrum**".

for

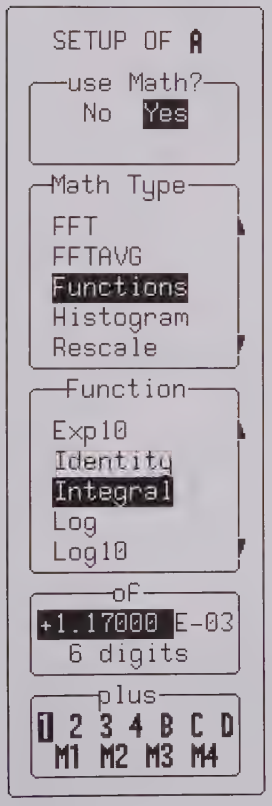
For selecting the number of sweeps.

of

To select the FFT source.

***Note:** FFT Average can be reset by pressing CLEAR SWEEPS. The number of currently accumulated waveforms is then shown in the Displayed Trace field of the function or its expansion.*

SETUP — Functions — gives access to a menu featuring a variety of display functions, listed below.



use Math?

To select "**Yes**".

Math Type

For selecting "**Functions**".

Function

To select a function type from the following list:

- "**Absolute value**"
- "**Derivative**"
- "**Exp (base e)**"
- "**Exp 10 (base 10)**"
- "**Identity**"
- "**Integral**"
- "**Log (base e)**"
- "**Log 10 (base 10)**"
- "**Negation**"
- "**Reciprocal**"
- "**Sinx/x**"
- "**Square**"
- "**Square root**"

of

For selecting the signal offset (used to compensate for any DC offset in the signal).

plus

For selecting the source trace.

Notes for Functions

Square root is computed on the absolute value of the source waveform.

For logarithmic and exponential functions the numerical value (without units) of the input waveform is used.

For the integral function the source waveform may be offset by an Additive Constant in the range -10^{16} to $+10^{16}$ times the vertical unit of the source waveform.

SETUP — Histogram* — used to select the histogramming function and set-up for parameter analysis.

use Math?

To select "**Yes**".

Math Type

For selecting "**Histogram**".

MORE HIST SETUP

To access the secondary menu offering more histogram settings.

FIND CENTER AND WIDTH

To calculate optimal center- and bin-width values for the histogram.

Histogram

To select up to five source parameters for histogramming.

using up to

For limiting the total histogram population.

* With WP03 Parameter Analysis or DDM/PRML Disk Drive Measurements/Supplementary Disk Drive Measurements packages only. *See* WP03 *or* DDM/PRML Operator's and Programming Manuals.

SETUP — Rescale

— for selecting a waveform and adjusting a, the multiplication factor, and b, the additive constant, in:

$$(a * \text{waveform}) + b,$$

where both constants can have values ranging between -10^{15} and $+10^{15}$.

use Math?

To select "**Yes**".

Math Type

For selecting "**Rescale**".

(a * 1) + b

To select "**a**" or "**b**".

a = or **b =**

The corresponding menu button for this menu highlights the mantissa, the exponent, or the number of digits, while the associated knob changes the highlighted value.

1 2 3 4 B C D
M1 M2 M3 M4

To select the source trace.

System Setup and Navigation

DISPLAY

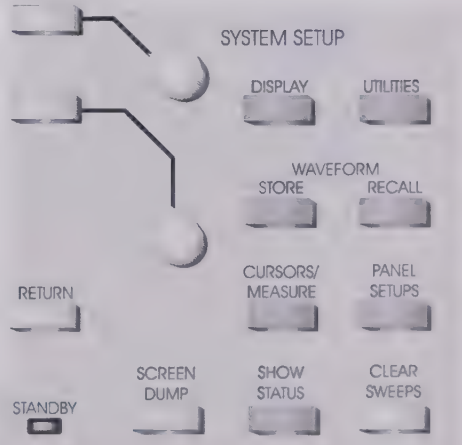
— each dark-gray menu-*entry* button, *such as the one shown here as an example*, activates a major set of on-screen menus (*see next page for particular button attributes*).

— the menu buttons running down alongside the screen enable selection from and navigation through individual on-screen menus.

RETURN

— is used to go back to a higher-level menu or, when at the highest possible level, to switch off that menu.

— the two menu knobs are associated with the two bottom-most menus, as well as their two associated menu buttons. Menu buttons and knobs provide dual control of certain menus. The button might be used to step through a list of parameters and choose one, while the knob sets the chosen parameter's value.



— entry to "DISPLAY SETUP": menus controlling display mode, grids, intensities, Dot Join, colors and Persistence menus. *Details Chapter 13.*

— entry to "UTILITIES": menus controlling hardcopy setups, GPIB addresses, special modes of operation etc. *Chapter 14.*

— entry to "STORE W'FORM": menus for storing waveforms to internal or external memory. *Chapter 15.*

— entry to "RECALL W'FORM": menus for retrieving waveforms stored in internal or external memory. *Chapter 15.*

— entry to "CURSORS" Setup: menus, for precise cursor measurements on traces; and "MEASURE": for precise parameter measurements. *Chapter 16.*

— entry to "PANEL SETUPS": menus for saving and recalling a configuration of the instrument. *Chapter 17.*

— prints or plots the screen display to an on-line hardcopy device, via the GPIB, RS-232-C or Centronics interface ports, or directly to an external thermal graphics printer. Hardcopies can also be generated as data files onto floppy, memory card or portable hard disk.

Once SCREEN DUMP is pressed, *all* displayed information will be copied. However, it is possible to copy the waveforms without the grid by turning the grid intensity to 0 with the "Display Setup" menu.

While a screen dump is taking place — indicated by the on-screen "PRINTING" or "PLOTTING" message — it can be aborted by pressing SCREEN DUMP a second time. It will take a certain amount of time for the buffer to empty before copying stops.

CLEAR SWEEPS

— restarts operations requiring several acquisitions, or sweeps, including averaging, extrema, persistence and pass/fail testing, by resetting the sweep counter(s) to zero.

SHOW STATUS

— menu entry to "STATUS", which shows summaries of the instrument's status regarding acquisition, system, etc. *Details Chapter 18.*

Auto Setup, Analog Persistence™ & Full Screen

The blue, green and light-gray buttons in the column on the right-hand side of the front panel activate a variety of important and useful functions.

— automatically scales the timebase, trigger level, offset, and volts/div to provide a stable display of repetitive signals.

- operates only on channels which are active. If no channels are on, then AUTO SETUP will operate on all channels, switching them all on.
- Signals detected must have an amplitude between 5 mV and 40 V, a frequency greater than 50 Hz, and a duty cycle greater than 0.1%.
- If signals are detected on several channels, the channel with the lowest number will determine the selection of the timebase and trigger source.

— activates LeCroy's unique Analog Persistence™ feature, providing an analog-oscilloscope view of signals while retaining the data-manipulation flexibility of a digital scope.

- rapidly accumulates multiple waveforms into dedicated three-dimensional display maps [time (x) vs volts (y) vs number of hits (z)] for each trace (1,2,3,4,A,B,C,D)
- renders each map to the screen to create an analog-style display

- provides user-definable, post-acquisition saturation control of each display map, so that detail can be easily drawn out of the 3-D waveform display
- and user-definable persistence decay, to decay entire maps over time, proportionally.

See the next chapter for more on this unique feature.

FULL SCREEN

— expands the waveform and grid to fill the entire display area.

General Instrument Reset: ***Simultaneously press the AUTO SETUP button, the top menu button, and the RETURN button. The scope will revert to its default power-up settings.***

Display Intelligence

A large, powerful display reveals the complete picture by managing color in a sophisticated and subtle way, giving on-screen objects depth, distinctness and association. The unique Analog Persistence™ feature offers advantages of an analog display in a digital oscilloscope. And the Full Screen function enlarges entire traces to fill the screen.

The display's use of color is intelligent as well as powerful. Traces can be shown either opaquely or transparently. Overlapping objects — traces over traces or grids — are always visible in transparent mode (*page 13–3*). Color and intensity are managed automatically in real time by a powerful hardware-supported system that has the added advantage of very low software-overhead.

Signals and their related data are color-associated (*13–2*). Each trace has its own dedicated color and persistence data maps. Backed by 1 MB of video memory, infinite and variable persistence displays are automatically color-matched to the parent trace. Related traces and text, screen icons, and parent–daughter zoom regions are also linked by color. As many as eight traces can be displayed at once, on as many grids (*13–10*).

There are seven pre-set color schemes, and four personal color palettes can be custom-created by the user (*13–20*), drawing on more than 40 different colors (*13–4*).

Analog Persistence (*13–5*), which uses the brightness level of a single color to denote relative signal intensities, is the scope's standard Persistence mode. Color-Graded Persistence (*13–5*), which uses a color spectrum from red through violet to map signal intensity, is also available. Both are infinite or variable with decay over time. They can be chosen from the DISPLAY SETUP menus. *see explanation starting page 13–5.*

Viewing Objects and Colors

The display is protean in its ability to transform and distinguish the on-screen objects:

- **— waveforms, including envelopes and intensified regions**
- **— grids**
- **— parameter measurements**
- **— cursors**
- **— status information, and**
- **— highlighted information (waveforms and text).**

These remain distinct and visible even when overlapping. Their identity, information and relationships with one another are always clear and visible.

Background Color

The color of the background (the expansive display area) also plays an important role in bringing out the links and differences between displayed objects. The choice of background colors has been expressly limited to the darker colors. And colors of displayed objects that are too close to the chosen background color are automatically deactivated so that objects always stand out from the background.

Trace–Color Association

The base color of a trace is specified for each color scheme. Howevér, the expanded or zoomed sections of a trace can be given their own colors, so that a single trace may have a number of colors at once — its principal color plus those of a number of expanded regions.

Text–Color Association

Trace-related text includes pieces of on-screen information that describe measurement parameters, cursors, triggers, waveforms and channels.

A standard text color covering all on-screen text exists in the pre-set color schemes, or can be chosen by the user for custom palettes. Waveform source descriptions, including parameter string, acquisition set-up, status screen and trigger information, will be in the trace color, even when contained in a text string (the remainder of which will be in the text color).

Waveform descriptor boxes — trace labels — and the information they contain always take the color of their respective trace.

Other Color Links

Most menus are displayed in the text color only. The active trigger-edge or -condition shows source-related information in the trace color, as does the trigger icon. But the titles of Channel Coupling menus are trace-colored, and Math Set-Up menu sources have their own color.

Overlap Management

Selection of the "**Opaque**" presentation of overlapping waveforms places one on top of another in normal, non-transparent layers. The order in which traces appear can be determined by the operator (*see below*).

However, when "**Transparent**" is chosen and overlap mixing used, those areas of the waveforms that overlap will automatically change color, chameleon-like, while grid intensity remains constant. But *unlike* the chameleon's transformation, this contrast enhancement marks the overlapping regions so that they stand out. Overlap-managed traces remain always discrete in relation to other displayed objects and the background.

Display Order

This is a further mechanism for recognizing displayed objects, which automatically overlays them on the screen in sequence.

When dealing with traces of the same type, the foremost trace is described in the top trace label at left-of-screen, the next in the second-from-top trace label, and so-on in descending order towards the background and the bottom of the screen, respectively. This order can be changed using the CHANNELS TRACE ON/OFF buttons.

When different types of traces are displayed, placed by default in ascending order from the grid at the bottom are: envelope traces, persistence traces, normal traces and — last and foremost on the screen — cursors. This sequence can also be customized.

For extrema waveforms the sequence is followed by a repeated scanning of normal traces, ensuring they are always viewed within extremas, regardless of display order. Thus each trace is visible within its envelope, persistence or Pass/Fail mask, grid lines never hide trace features, and cursors are always visible.

Neutral Highlighting

Any color can be chosen as "neutral" in the four user color schemes, and a neutral color is designated by default in each of the seven pre-set schemes. This designated neutral color automatically relegates display objects of limited interest — the area *outside* the measurement-gate region — thus indirectly highlighting the area of greatest interest, that *inside* the gated region.

Pass/Fail Testing

When overlap mixing is used for Pass/Fail mask testing, together with a well-selected color scheme — default scheme "1", for example — and the measurement-gate highlighting described above, the trace area outside the mask is placed in clear relief.

THE COLORS			
White	Dark Cyan	Ocean Spray	Fuchsia
Cyan	Cream	Ice Blue	Raspberry
Yellow	Sand	Pastel Blue	Neon Pink
Green	Amber	Pale Blue	Pale Pink
Magenta	Olive	Sky Blue	Pink
Blue	Light Green	Royal Blue	Vermilion
Red	Jade	Deep Blue	Orange
Light Gray	Lime Green	Navy	Cerise
Gray	Apple Green	Plum	Khaki
Slate Gray	Emerald Green	Purple	Brown
Charcoal Gray	Grass Green	Amethyst	Black

Setting Up the Display

DISPLAY SETUP

Press

to access the DISPLAY SETUP menus (*see page 13–11)* and select from:

- **"Standard" or "XY" mode and grids**
- **Persistence**
- **Dot Join**
- **"Single", "Dual" or "Quad" grids**
- **Display and grid intensities**
- **"More Display Setup" menus.**

Standard or XY Display?

Standard display (*13–11*) allows presentation of source waveforms versus time (or versus frequency for FFTs).

XY display (*13–16)* compares and contrasts one source waveform with another, and is used when selected traces have the same time or frequency span (time/div) and horizontal unit (in seconds or Hertz). XY is automatically generated as soon as two compatible traces are selected. If incompatible traces are selected, a warning message is displayed at the top of the screen. And if compatible traces are not matched in time, their XY diagram will be displayed showing the shifting in time or in frequency between them. (The ΔT or Δf indicator is displayed in the Displayed Trace Label at left-of-screen.)

Using Persistence

Both Persistence modes, Analog Persistence™ and Color Graded Persistence, are able to be used in either Standard or XY display. Points are shown accumulating on-screen over many acquisitions. Eye diagrams and constellation displays can be made using persistence, and the most recent sweep can be displayed as a "vector" trace over the Persistence display.

Persistence is activated by pressing

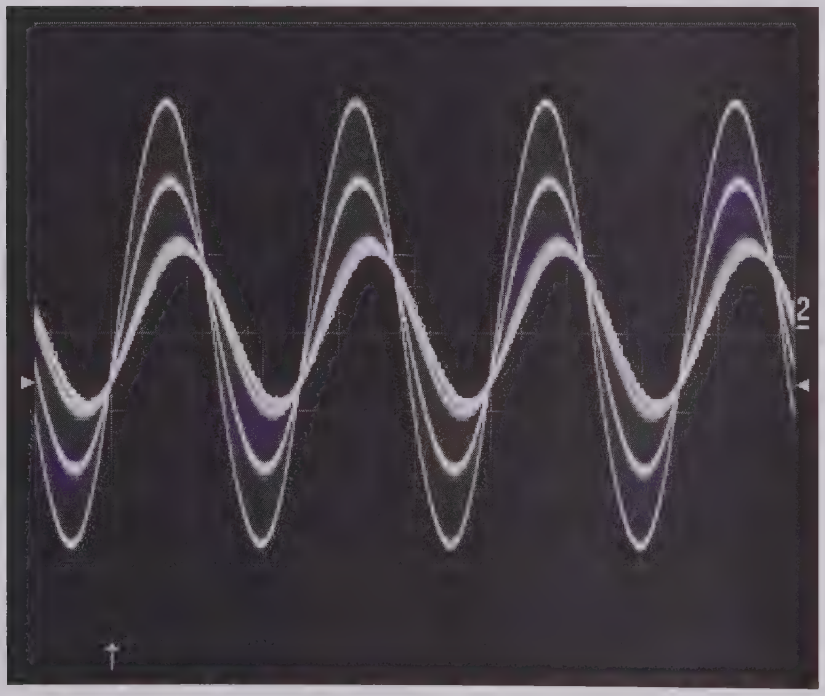
or by selecting the "DISPLAY SETUP" "Persistence" menu (*13–11*), whose menu button toggles with it.

Choosing Grids

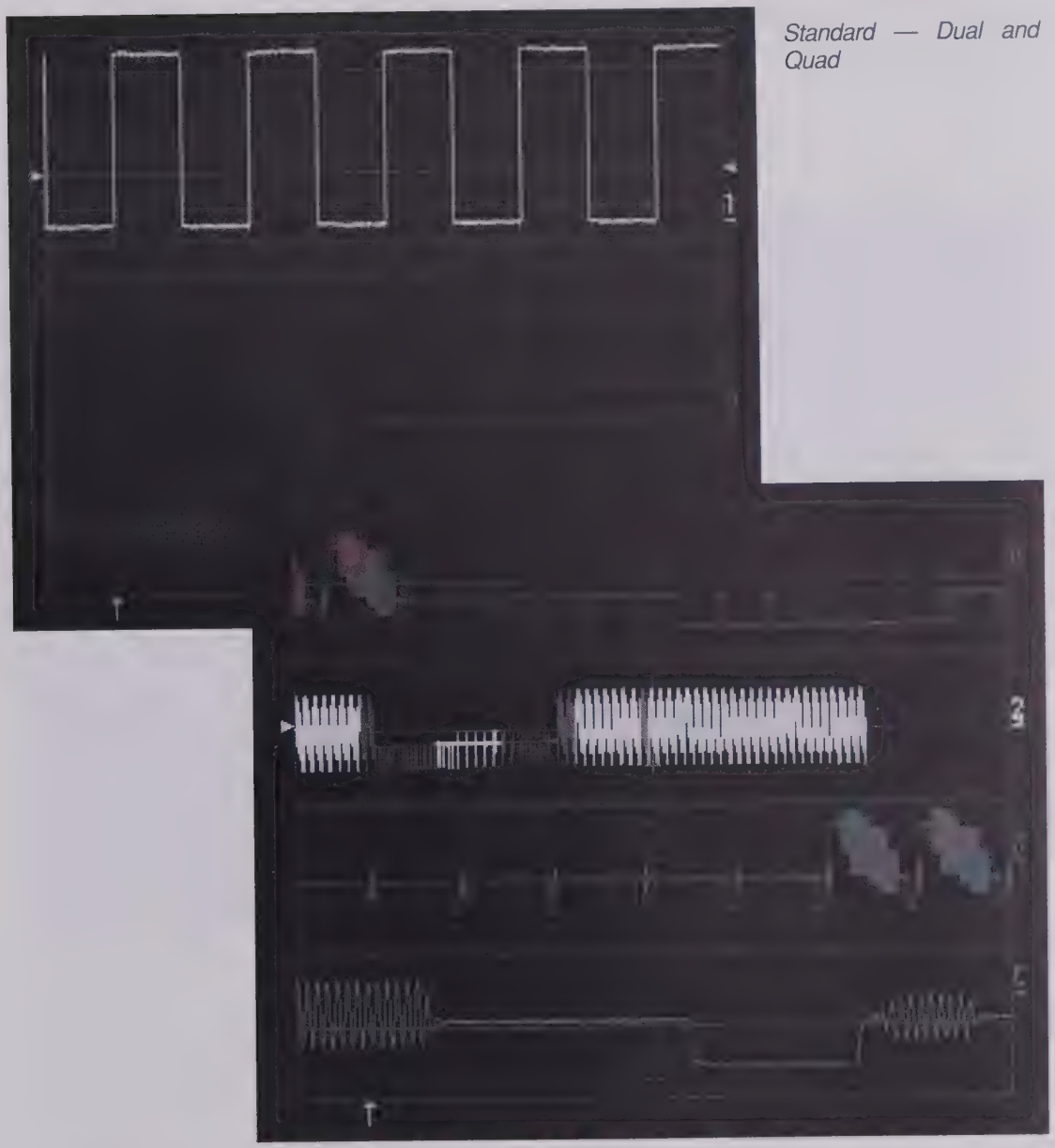
Between one and eight traces can be shown on up to eight grids. A variety of grid styles offer different ways of viewing traces. These styles are: Standard Single, Dual, Quad and Octal (eight-grid); XY, Single + XY, and Dual + XY; and Single–, Dual–, Quad– and Octal– Parameter. Each of these styles can be expanded to fill the entire screen using Full Screen.

Their graticules are internally generated, with separate intensity control for grids and waveforms. Grids can be blended with displayed traces as desired.

Examples of grid styles available are illustrated here and on the following pages...

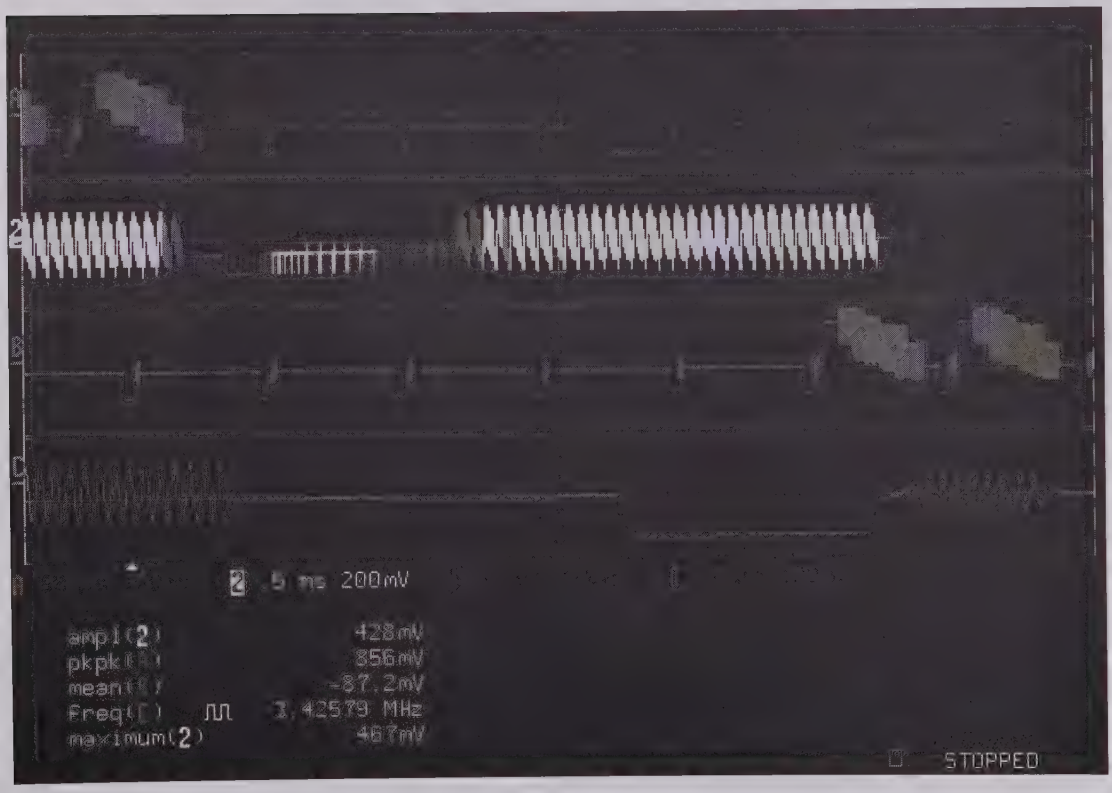


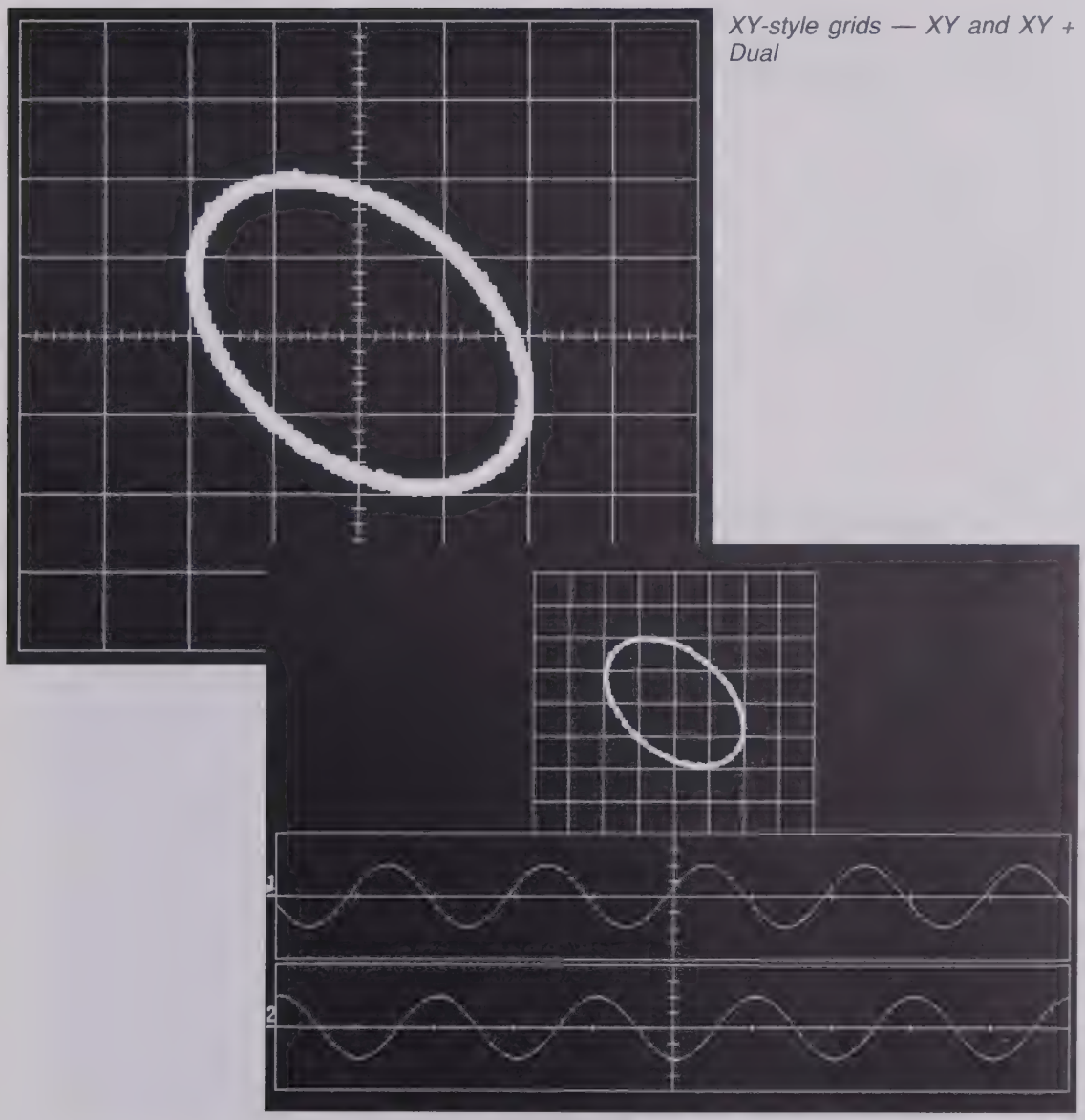
Standard — Single



Standard — Dual and Quad

Parameter — Quad — Full Screen (Note that trace information normally contained in the trace labels is arranged beneath the grid in Full Screen mode.)





XY-style grids — XY and XY + Dual

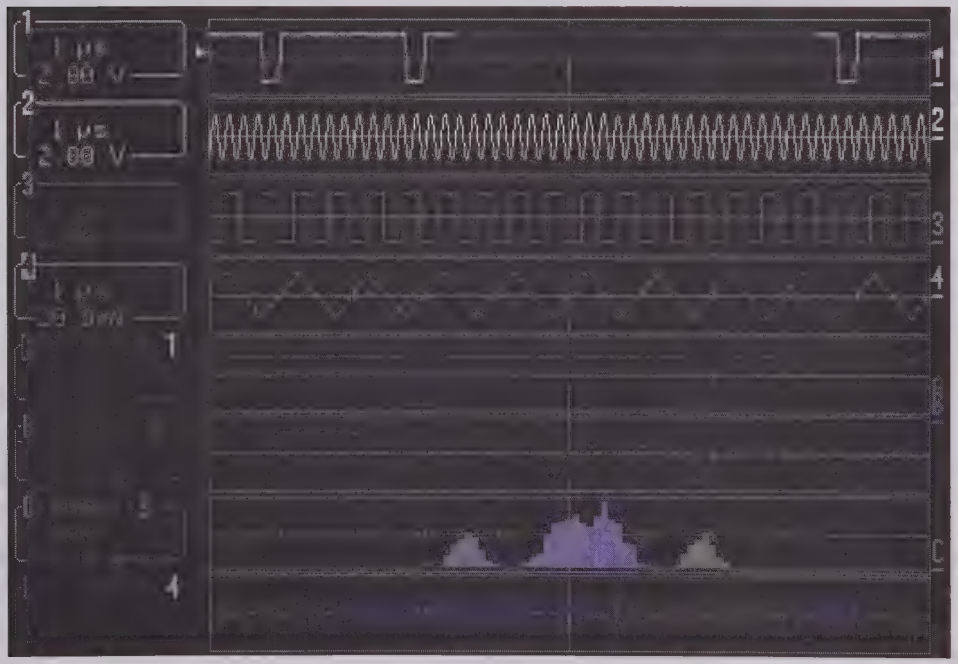
Eight-Trace and Octal Display

As many as eight traces can be displayed at once, with their respective trace labels and any combination of math, zoom and memories. When "Octal" is selected from the "Standard" "Grids" menu (*see next page*), eight separate grids are made available.

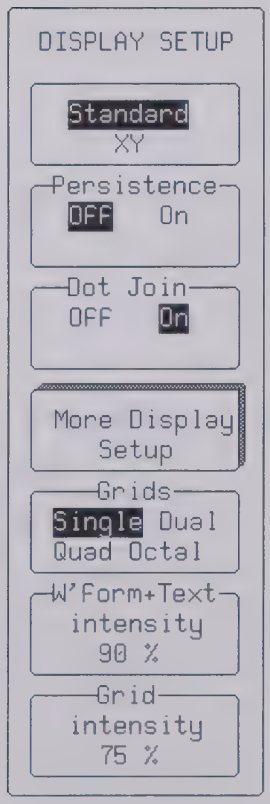
Displaying up to 8 Traces

When more than four traces are displayed in Single-, Dual- or Quad-grid style, the accompanying trace labels become smaller so that as many as eight labels can be shown. While in Octal, the labels are always smaller.

Octal-style grid, with eight displayed traces and their labels.



DISPLAY SETUP — Standard



With "**Standard**" selected, these menus become accessible.

Persistence

For activating Persistence (*see next menu*). Coupled to the ANALOG PERSIST button.

Dot Join

To select Dot Join "ON" — connecting the sample points with a line segment — or "OFF", when only the sample points are displayed.

More Display Setup

For accessing the "MORE DISPLAY" menus (*13–20*).

Grids

For selecting the number of grids.

W'form + Text intensity

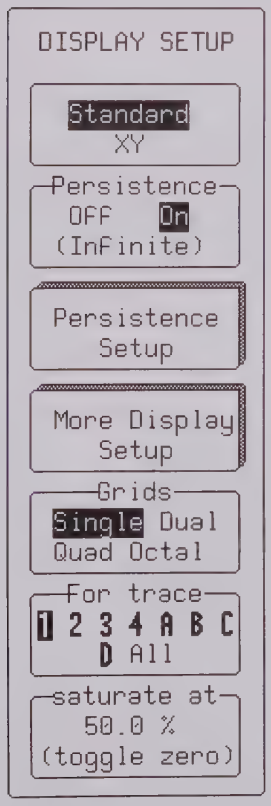
Adjusts the screen intensity for the waveform and associated text, using the attributed menu knob.

Grid

Adjusts the screen intensity of the grid, using the attributed menu knob.

***Note:** If grid intensity is turned down to 0 %, the screen goes black! Press the DISPLAY button to return automatically to 90 % intensity.*

DISPLAY SETUP — Standard — Persistence "On"



With both "**Standard**" and "Persistence" "**On**" selected in the first menu, these menus appear.

Persistence

For activating Persistence. When "**On**", this can be cleared and reset by pressing the CLEAR SWEEPS button or by changing any acquisition condition or waveform processing condition. This menu button toggles with the ANALOG PERSIST button.

Persistence Setup

To access the "PERSISTENCE" menus (*see next page*)

More Display Setup

For accessing the "MORE DISPLAY" menus (*13–20*).

Grids

For selecting the number of grids.

For trace

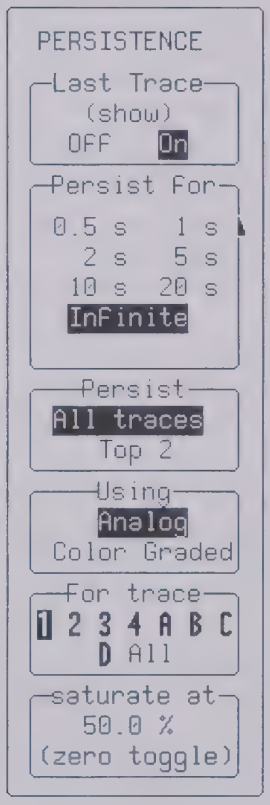
To select the trace or traces on which persistence is to be applied.

saturate at

For selecting the percentage of saturation. A level of 100% corresponds to the color spectrum being spread across the entire depth of the persistence data map. At lower values, the spectrum will saturate (brightest color or shade) at the specified percentage value. Lowering the percentage causes the pixels to be saturated at a lower data intensity, and allows rarely-hit pixels that are not seen at higher percentages to become visible.

PERSISTENCE

These menus appear when "Persistence Setup" is selected from "DISPLAY SETUP".



Last Trace

To show — when "**On**" — the last acquired trace.

Persist for

For selecting the persistence duration, in seconds.

The number of sweeps accumulated — up to 1 million — is displayed below the grid.

Persist

To select whether persistence is applied to all or to the top two traces.

Using

To select the Persistence Mode. With "**Analog**" selected, each persistence data map is rendered to the screen in various intensities of the trace color. While with "**Color Graded**", all persistence data maps are rendered in a red–to–violet spectrum.

For trace

To select any or all of the displayed traces — "**On**" (*top menu*) — for saturation adjustment.

saturate at

For selecting the percentage of saturation. A level of 100% corresponds to the color spectrum being spread across the entire depth of the persistence data map. At lower values, the spectrum will saturate (brightest color or shade) at the specified percentage value. Lowering the percentage causes the pixels to be saturated at a lower data intensity, and allows rarely-hit pixels that are not seen at higher percentages to become visible.

ANALOG PERSISTENCE™ — Analog Speed *and* Digital Flexibility

LeCroy's unique Analog Persistence feature offers the advantages of analog display in a leading-edge Digital Storage Oscilloscope (DSO). The display *looks* like an analog display. It's fast, like analog. But it offers the data manipulation, flexibility and statistical analysis capabilities only a digital scope can provide.

With traditional analog instruments, data manipulation and the direct comparison of acquisitions is practically impossible. Statistical analysis is difficult, too. Historically, digital technology changed all that. Sampling the signal and holding it in digital memory has made signal analysis — and diagnosis — simple.

However, analog does have some advantages. Because there is no analog–to–digital conversion, it's faster. The speed of the analog scope is limited only by the bandwidth of its electronics. The instrument monitors signals almost continuously. Whereas the standard DSO must capture signals across the time period allowed by the size of its acquisition memory. Then it must process and display their representation. The time needed to process the previous acquisition limits its speed.

Analog Persistence has now changed that, too. While maintaining digital data-manipulation flexibility, this innovation emulates analog display and shares its advantages. And offers other new digital features.

LeCroy DSOs featuring Analog Persistence are fast. This is because data- accumulation is decoupled from display. New data is both accumulated and displayed more quickly.

Analog Persistence also provides variable persistence. The displayed image shows the changes in the sample event over time. Statistical integrity is preserved because the decay is proportional to the persistence population for each amplitude- or time-combination in the data.

The Analog Persistence display is generated by repeatedly sampling amplitudes of events over time and accumulating the sampled data into a persistence map that records population information for amplitude and time combinations.

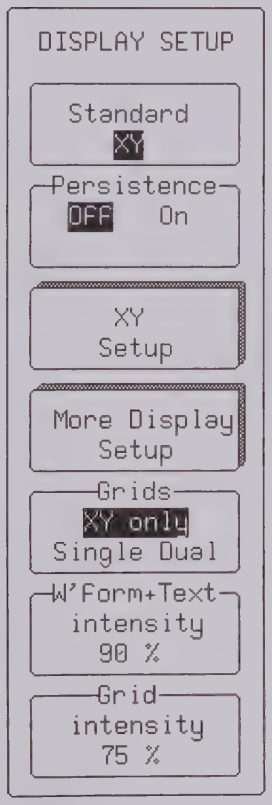
Each channel and its associated persistence data map are assigned a single color. As a persistence data map is rendered to the screen, different shades of its color are assigned to the population ranges between a minimum and a maximum population. The maximum population automatically receives the brightest shade, the zero or smallest population the darkest shade or the background color, and the population ranges between zero and the maximum population the shades in between.

The information in the lower populations, or down at the noise level — the random transients rather than the dominant signals — can often be of greater interest. Analog Persistence allows the distribution of data in these lower populations to be highlighted and examined in more detail.

The user can select a saturation level or population specified as a percentage of the maximum population. Then all populations above the saturation population are assigned the brightest shade — that is, they are saturated. Whereas all populations below the saturation level are assigned the remaining shades from brightest to darkest.

Data populations and their displayed shades are dynamically updated as data from new acquisitions are accumulated.

DISPLAY SETUP — XY When "XY" is selected in the first menu, these other menus appear.



Persistence

For activating Persistence.

XY Setup

For accessing "XY SETUP" (*see next page*).

More Display Setup

For accessing the "MORE DISPLAY" menus.

Grids

For selecting the grid style.

W'form + Text intensity

Adjusts the screen intensity for the waveform and associated text, using the attributed menu knob.

Grid intensity

Adjusts the screen intensity of the grid, using the attributed menu knob.

XY SETUP

When the corresponding menu button for "XY Setup" is pressed and when "Persistence" is "OFF", these menus appear:

Using

To select "Analog" or "Color Graded" treatment of **a single sweep**.

saturate at

For selecting the percentage of saturation. At lower values, the spectrum will saturate (brightest color or shade) at the specified percentage value. Lowering the percentage causes the pixels to be saturated at a lower data intensity, and allows rarely-hit pixels that are not seen at higher percentages to become visible.

DISPLAY SETUP — XY — PERSISTENCE "ON"

When "**XY**" is selected in the first menu and Persistence activated, these menus appear:

Persistence

To turn Persistence "**On**".

XY–Persist Setup

For accessing "XY SETUP" using Persistence (*see next page*).

More Display Setup

For accessing the "MORE DISPLAY" menus.

Grids

For selecting the grid style.

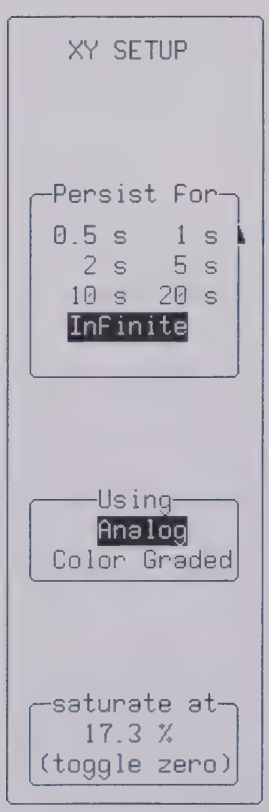
W'form + Text intensity

Adjusts the screen intensity for the waveform and associated text, using the attributed menu knob.

Grid intensity

Adjusts the screen intensity of the grid, using the attributed menu knob.

DISPLAY SETUP — XY–PERSIST SETUP



When the corresponding menu button for "XY–Persist Setup" is pressed, these menus appear:

Persist for

For selecting the persistence duration, in seconds. The number of sweeps accumulated — up to 1 million — is displayed below the grid.

Using

To select "**Analog**" or "**Color Graded**" Persistence.

saturate at

For selecting the percentage of saturation. A level of 100% corresponds to the color spectrum being spread across the entire depth of the persistence data map. At lower values, the spectrum will saturate (brightest color or shade) at the specified percentage value. Lowering the percentage causes the pixels to be saturated at a lower data intensity, and allows rarely-hit pixels that are not seen at higher percentages to become visible.

Controlling Color

MORE DISPLAY

Press the menu button beside the "More Display Setup" menu to gain direct access to the main color controls.

Screen save

"**On**" will activate the built-in screen saver, which cuts in 10 minutes after the last use of a front-panel control. This is a complete display shut-down of the internal screen, giving not only screen-saving, but lower power dissipation and system noise. However, the external monitor does remain active. The front-panel LED light indicates that the scope is in screen-saving, STANDBY, state.

STANDBY

Press any front-panel control to restore the screen.

Color Scheme

To select from seven pre-set ("**1**", "**2**", "**3**", "**4**", "**5**", "**6**", "**7**"), or four customized user ("**U1**", "**U2**", "**U3**", "**U4**"), color schemes. When a user scheme is chosen, "CHANGE COLORS" is added to the list of menus. And when selected, this menu enables the creation of personal color palettes and the assigning of colors to traces, grids, or any other displayed object or element (*see panel, facing page*). It also allows pre-set schemes to be copied for easier customizing.

CHANGE COLORS

This menu appears when one of the four custom color schemes is selected from the "Color Scheme" menu (*above*). It accesses the "CHANGE COLORS" secondary menu (*13–22*).

Trace color

For selecting either "**Opaque**" or "**Transparent**". When the latter is chosen, waveform objects are always visible and their overlapping regions automatically distinguished by a new and unique color.

When dealing with traces of the same type, the foremost trace is described in the top trace label at left-of-screen, the second-foremost in the second-from-top trace label, and so-on in descending order towards the background and the bottom of the screen, respectively. This order can be changed using the CHANNELS TRACE ON/OFF buttons. *For a variety of trace types, the order follows that described on page 13–4.*

Measure Gate

To highlight ("**On**") the gated parameter region (*see* "MEASURE" "Parameters") by making the region *outside* the parameter a neutral color.

Data Points

To show the data (sample) points in "**Normal**" or "**Bold**" view.

Choosing Color Palettes

The seven pre-set ("1–7") and four user-selected custom color schemes ("U1–4") give a particular color to each displayed object. Colors are assigned to the custom palettes using the "CHANGE COLORS" "Change" menu (*see next page*) for:

"Background" — background color of entire display area

"Trace 1...4" — color assigned to traces displaying Channel 1, 2, 3, or 4

"Trace A...D" — assigned to Trace A, B, C, or D.

"Grid" — default color of Grid.

"Text" — assigned to menus, acquisition-status and non-single source measurements.

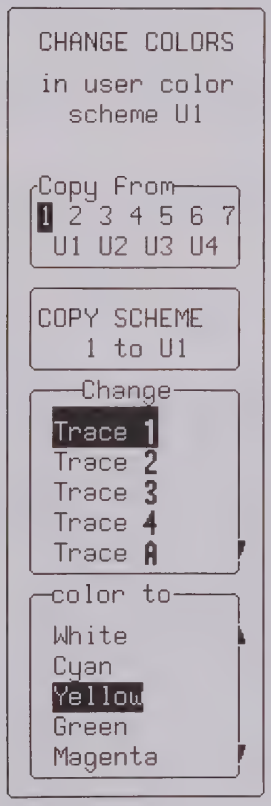
"Cursors" — assigned to cursors

"Warnings" — assigned to error and warning messages

"Neutral" — color designated as neutral (can be any color in user palettes), used in 'Measure-Gate' region highlighting.

"Overlays" — assigned to the menus overlaid on the grid when in Full Screen mode.

CHANGE COLORS



— enables colors to be assigned to displayed objects and the user-customizing of color schemes.

Copy from

For copying one of the seven pre-set color schemes ("**1**", "**2**", "**3**", "**4**", "**5**", "**6**", or "**7**") to a user color scheme ("**U1**", "**U2**", "**U3**", or "**U4**"), or a user scheme to another. Copying make customizing easier by forming the basis of a personalized palette.

COPY SCHEME

For executing the copying of the pre-set scheme to the personal color palette.

Change

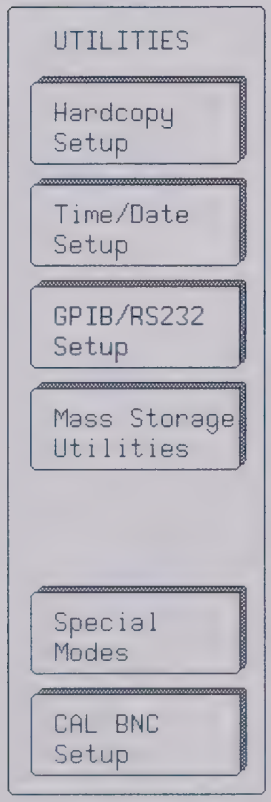
To select a displayed object for color assignment (*see panel, previous page for details*).

color to

For selecting the color to be assigned to the chosen object.

Printing, Storing, Using Special Modes

UTILITIES



Press UTILITIES to access the primary menus for:

- — Hardcopy settings
- — Time and date settings for the real-time clock
- — GPIB and RS232 settings
- — Mass storage utilities (including copy and format and delete files)
- — Special modes of operation (offset behavior, sequence time-out, cursor units, auto-calibration, etc.)
- — Signal function at the CAL BNC connector (magnitude, frequency, shape, trigger out, pass/fail use)

Hardcopy Setup (*see page 14–2*)

To access secondary menu for viewing, changing printer settings.

Time/Date Setup (*14–4*)

To access secondary menu for adjusting the real-time clock displayed in the upper left-hand corner of the screen.

GPIB/RS232 Setup (*14–5*)

To access secondary menu for viewing, changing interface settings.

Mass Storage Utilities (*14–10*)

For accessing the "Mass Storage Utilities" menus.

Special Modes (*14–19*)

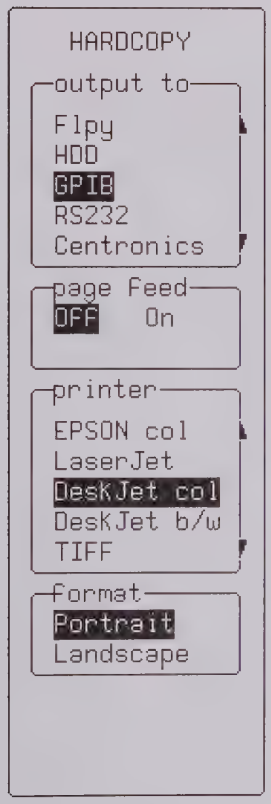
For accessing the "Special Modes" menus.

CAL BNC Setup (*14–22*)

For accessing the "CAL BNC" menus.

Hardcopy Setup

HARDCOPY



output to

To select the device to which the instrument is to output. This menu shows the options installed in the instrument. The device can be either a port — GPIB, RS232 or Centronics — to which a printer is connected, a storage unit such as Floppy or portable hard disk (HDD), or the internal printer. If a port, the "GPIB & RS232" menu should be checked to ensure settings are correct.

File names are assigned automatically when copying to storage units.

page feed

For starting (when "**On**" is selected) a new page each time SCREEN DUMP is pressed.

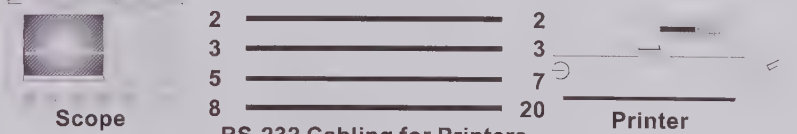
Press SCREEN DUMP to make a copy of the screen display.

printer

To select the type of printer, or graphics file format ("**TIFF**", "**BMP**") protocols, using the corresponding menu buttons or knob.

format

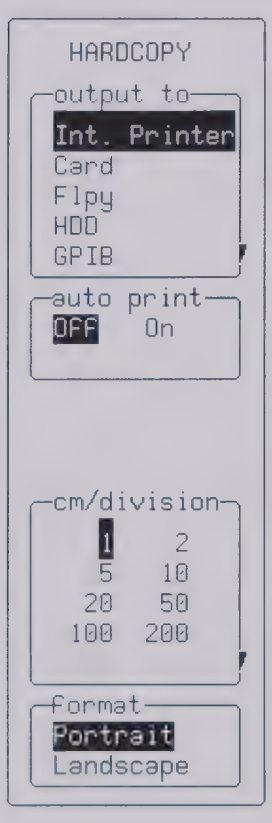
For choosing either "Portrait" or "Landscape" formats.



RS-232 Cabling for Printers
(can be used in almost every case)

See also page 14–6

HARDCOPY — Internal Printer*



output to

For selecting "**Int. Printer**".

auto print

For generating ("**On**") a hard copy of the screen and send to the internal printer after every acquisition.

cm/division

For selecting the expansion factor.

format

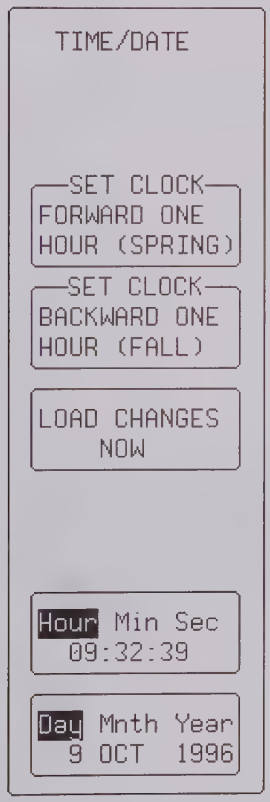
For choosing either "Portrait" or "Landscape" formats.

***Note:** A "persistence" trace cannot be expanded, nor do cursors show on an expanded printout.*

* Option.

Time/Date Setup

TIME/DATE



SET CLOCK FORWARD ONE HOUR

For changing to summer time.

SET CLOCK BACKWARD ONE HOUR

For changing back to standard time.

LOAD CHANGES NOW

To activate the changes made with the "Hour Min Sec" and "Day Mnth Year" buttons and knobs (*see below*).

Hour/Min/Sec

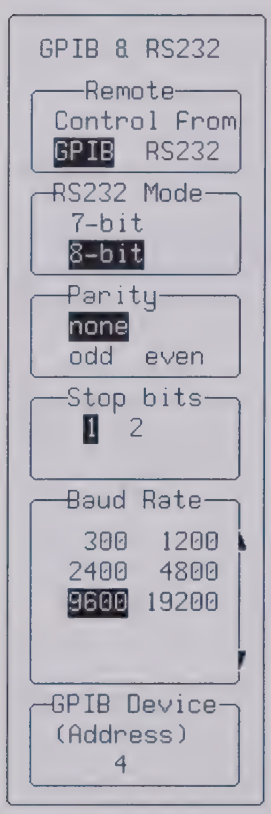
Using the corresponding menu button, for toggling between "**Hour**", "**Min**"utes, and "**Sec**"onds, and the associated menu knob to adjust the value.

Day/Mnth/Year

Using the corresponding menu button, for toggling between "**Day**", "**Mnth**", and "**Year**", and the associated menu knob to adjust the corresponding value.

GPIB/RS232 Setup

GPIB & RS232



Remote Control from

For selecting the port for remote control.

*Note: When "**RS-232**" is selected, the GPIB interface is in "Talk Only" mode.*

RS232 Mode

To select "**7–bit**" or "**8–bit**" mode for RS-232 communication.

Parity

To select the "**odd**" or "**even**" parity, or "**none**", for RS-232 communication.

Stop bits

For selecting the number of stop bits for RS-232 communication.

Baud Rate

To set the Baud Rate for RS-232 communication using the attributed menu knob.

GPIB Device (Address)

To choose the appropriate GPIB address.

***Note**: Any change becomes effective immediately.*

RS-232-C Connector

The RS-232-C port on the rear panel can be used for remote operation of the oscilloscope, and for direct interfacing to a hard-copy device for copying of displayed waveforms and other screen data.

The RS-232-C port of a printer unit connected to the scope can be computer-controlled from a host computer using the GPIB port.

However, the oscilloscope's built-in drivers allow hard copies to be made without an external computer.

RS-232-C Connector Pin Assignments†

DB9 Pin No.	Line Name	Description
3	T × D	*Transmitted Data* (from the oscilloscope).
2	R × D	*Received Data* (to the oscilloscope).
7	RTS	*Request To Send* (from the oscilloscope). If the software Xon/Xoff handshake is selected, it is always TRUE. Otherwise (hardware handshake) it is TRUE when the oscilloscope is able to receive characters and FALSE when the oscilloscope is unable to receive characters.
8	CTS	*Clear To Send* (to the oscilloscope). When TRUE, the oscilloscope can transmit; when FALSE, transmission stops. It is used for the oscilloscope output hardware handshake.
4	DTR	*Data Terminal Ready* (from the oscilloscope). Always TRUE.
5	SIG GND	*Signal Ground*

† Corresponds to a DTE (Data Terminal Equipment) configuration.

Mass Storage Utilities

The "MASS STORAGE" menu (*14–10*) gives access to the mass-storage file system controls. The system supports storage and retrieval of data files to and from memory cards, floppy disks and removable hard disk media.

Memory Card Format

The Memory Card structure, based on the PCMCIA II / JEIDA 4.0 standard, and as found in any DOS floppy or hard disk, consists of a DOS partition containing files. The oscilloscope formats the card in segmented contiguous sectors, each of 512 bytes. The scope does *not* support error-detection algorithms such as CRCs or checksum inserted between the sectors, and when this is done the instrument may only be able to read, but not write, the card.

Floppy Disk Format

The floppy supports DOS 1.44 MB and 720 kB formats.

Hard Disk Format

The hard disk structure is based on the PCMCIA III / JEIDA 4.0 standard. The media is arranged as a DOS partition containing files as in any DOS floppy or hard disk.

The hard disk format uses 512 bytes per sector and four sectors per cluster. One cluster is the minimum file size: any files smaller than 2048 bytes in size will still use one cluster's allocation of 2048 bytes of disk space.

Subdirectories

All files are written to and read from the media from the current working directory. The default name of the working directory is LECROY_1.DIR. This directory is automatically created when the media is formatted. If the media is formatted elsewhere — for instance on a PC — the directory will be created the first time a file is stored to the memory card, floppy disk or hard disk. .

The working directory can be changed to any valid DOS directory name, using the file-name preferences menu. All working directories are created as sub-directories from the root directory.

The maximum number of files allowed in any one directory is 2400.

File-naming Conventions

As in MS-DOS, the file name can take up to eight characters followed by an extension of three characters.

A file is treated as:

- Panel setup if its extension is PNL
- Waveform if its extension is a three-digit number
- Waveform template if its extension is TPL
- Hardcopy if its extension is TIF, BMP, or PRT.

Note: *If the new file being stored bears the same name as that of an existing file on the same medium, the old file will be deleted.*

The instrument has a pre-defined naming convention for the eight-character file names and directory names, and these default names can be customized, as shown in this table.

Type	Default Name	Customized Name
Manually stored waveform files	Stt.nnn	xxxxxxxx.nnn
Automatically stored waveform files	Att.nnn	xxxxxxxx.nnn
Panel files	Pnnn.PNL	xxxxxnnn.PNL
Hard copy files	Dnnn.TIF Dnnn.BMP Dnnn.PRT	xxxxxnnn.TIF xxxxxnnn.BMP xxxxxnnn.PRT
Template files	LECROYvv.TPL	Cannot be changed
Directory name	LECROY_1.DIR	xxxxxxxx
Spreadsheet	Sttnnn.TXT	xxxxxnnn.TXT
Matlab	Sttnnn.DAT	xxxxxnnn.DAT
Mathcad	Sttnnn.PRN	xxxxxnnn.PRN

Where:

- *'x' is any legal DOS file-name character*
- *'tt' defines the trace name of C1, C2, C3, C4, TA, TB, TC, TD*
- *'nnn' denotes a 3-digit decimal sequence number starting at 001 that is automatically assigned*
- *'vv' is the template version number. If the version is 2.1 for example, the template will be saved as LECROY21.TPL*
- *Extension 'TIF' or 'BMP' denotes hardcopy graphics image files*
- *Extension 'PRT' denotes hardcopy printer files.*

Auto-Store Waveform File Naming

The default notation for waveform files is Stt.nnn for manually stored files and Att.nnn for automatically stored files, the characters S and A representing the two storage methods, respectively.

When automatically generating a file name, the system uses the assigned name plus a three-digit sequence number. If the assigned waveform name is already in the default 'Stt' form — such as SC1, STB — the name will be modified to the 'Att' form: AC1, ATB and so on. All other user-assigned names remain as entered.

More on Auto-Stored Files

If "**Fill**" is selected and default names are used, the first waveform stored will be Axx.001, the second Axx.002, and so on, continuing until the storage medium is filled, the file number reaches 999, or there are more than 2400 files in the current working directory.

If "**Wrap**" is selected, the oldest auto-stored waveform files will be deleted whenever the medium becomes full. And the remaining auto-stored waveform files will be renamed — the oldest group of files will be named "Axx.001", the second oldest "Axx.002" and so on.

The current sequence number is deduced from inspection of all file names in the working directory, regardless of file type — panel, hard copy or waveform. The highest occupied numeric file-name extension of the form 'nnn' is determined, and the next highest number is used as the current generation number for storage operations.

Deleting Files

When a file generation is deleted, all files designated with the three-digit sequence number of the file-name extension will be deleted, regardless of file type.

Media Size/Storage Availability

The mass-storage file system indicates media size and storage availability in kbytes where 1 kbyte = 1024 bytes. Many media manufacturers specify the available storage in Mbytes where 1 Mbyte = 1 million bytes. This results in an apparent mismatch in specified versus actual media storage availability, when in fact the availability in bytes is identical.

Write Protect Switch

If the write-protection switch of the card or floppy being used has been pushed to the active position, the message "Device is Write

Protected" will be displayed on the upper part of the grid whenever the medium is accessed for writing.

SRAM Card Battery

The SRAM memory card contains a button-size battery for preserving data. When this needs replacing, the message "BAD BATTERY" appears. The battery can and should be changed while the memory card is still in the oscilloscope, in order to prevent loss of information. To access the battery, remove the panel on the bottom edge of the card by removing the small screw.

MASS STORAGE

— offers the primary menus for controlling mass storage.‡ These are:

Memory Card Utilities or

Floppy Disk Utilities or

Hard Disk Utilities

Each of these three menus is used to delete files, format, or copy a machine template onto its respective medium. *See following pages for examples.*

Mass Storage Preferences

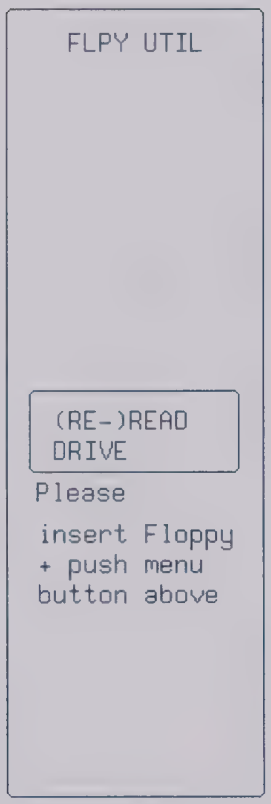
To set, add or delete it a working directory, or for customizing file names. *Page 14–16.*

File Transfers

For copying files from one storage device to another. *Page 14–15.*

‡ The range of "Utilities" available depends on the options installed.

FLPY UTIL



These menus appear when "Floppy Disk UTILITIES" is selected from "MASS STORAGE" and

- a new floppy is inserted
- there is no floppy in the drive.

(RE–)READ DRIVE

To read the floppy and display directory contents.

FLPY UTIL

Once the floppy has been read, these menus appear, displaying information on the installed storage media:

- Last "format" date and time
- Media size and available free space
- Date, time and size information of the selected file on the media.

TEMPLATE AND FORMATTING

To access a secondary menu for formatting storage media or copying to it the machine template. The template is an ASCII text-file containing all information required for decoding the descriptor part of a binary waveform.

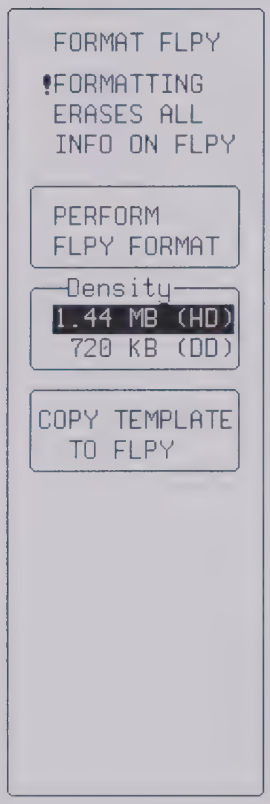
DO DELETE

To delete the file selected in the "File" menu (*below*).

File

For selecting the file to be deleted with the attributed menu knob or buttons.

FORMAT FLPY



These menus appear when "TEMPLATE AND FORMATTING" is selected from "FLOPPY UTIL".

PERFORM FLPY FORMAT

To format the floppy, in DOS format with an interleave factor of two, which optimizes throughput to and from the scope.

Density

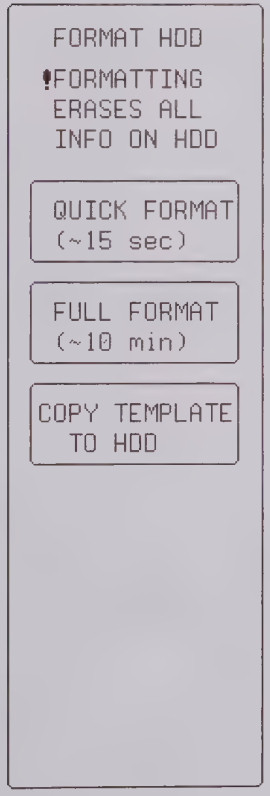
This menu appears only in "FORMAT FLOPPY". For selecting density — "**1.44 MB (HD)**" or "**720 kB (DD)**".

COPY TEMPLATE TO

For copying the machine template — an ASCII text-file containing all the information required to decode the descriptor part of a binary waveform — to the medium.

FORMAT HDD

These menus appear when "MASS STORAGE" "Hard Disk Utilities" "TEMPLATE AND FORMATTING" is selected.



QUICK FORMAT

To quickly (15 seconds) clear the portable hard disk drive.

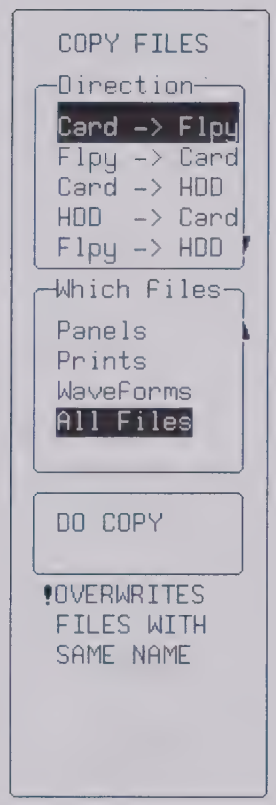
FULL FORMAT

For a complete formatting of the HDD — recommended if the disk is non-readable.

COPY TEMPLATE TO

For copying the machine template — an ASCII text-file containing all the information required to decode the descriptor part of a binary waveform — to the medium.

COPY FILES



These menus appear when "MASS STORAGE" "File Transfers" is selected, and copies files from one medium to another.

Direction[§]

To select source (copy from) and destination (copy to).

Which files

For selecting the type of file for copying.

DO COPY

To execute the copying.

[§] Depending on the options installed.

PREFERENCES

These menus appear when "MASS STORAGE" "Mass Storage Preferences" is selected and are for:

- Selecting the working directory
- Deleting a directory
- Accessing the "File Name Preferences" menu
- Accessing the "Add New Directory" menu.

on drive

For selecting the medium.

File Name Preferences

To access the secondary menu for defining custom names for waveform, setup, or hardcopy files (*see next page*).

DELETE THIS DIRECTORY

To delete the directory selected in "**work with**" menu (*see below*).

work with

For selecting the directory to be used for file storage and retrieval.

Add new Directory

To access secondary menu for adding a new directory.

FILENAME PREF

This menu appears when "File Name Preferences" is selected from the preceding menu — for defining custom names for waveform, setup, or hardcopy files.

to be set to:

To select the character for modification.

RESTORE DEFAULT NAME

For restoring the file type selected in the "File Type" menu (*see below*) to its default name.

ENTER NEW FILE NAME

To validate the newly defined name.

BACKSPACE

For moving back one space and erasing the previous character.

INSERT

To move forward to create a space for insertion of a character.

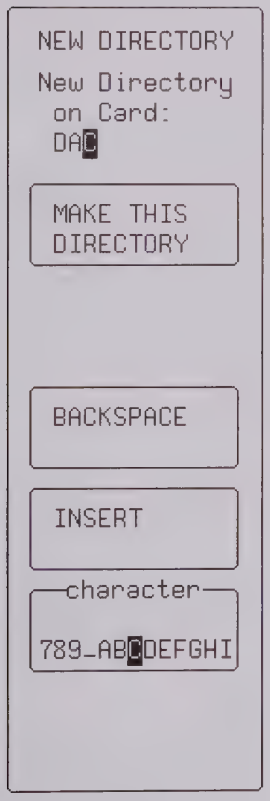
character

For selecting a character using the menu knob.

File Type

To select the file type for customizing.

NEW DIRECTORY — used to define a new directory with a custom name.



New Directory on Card:

For selecting the character to be modified.

MAKE THIS DIRECTORY

For validating the new directory.

BACKSPACE

To move back one space and erase the previous character.

INSERT

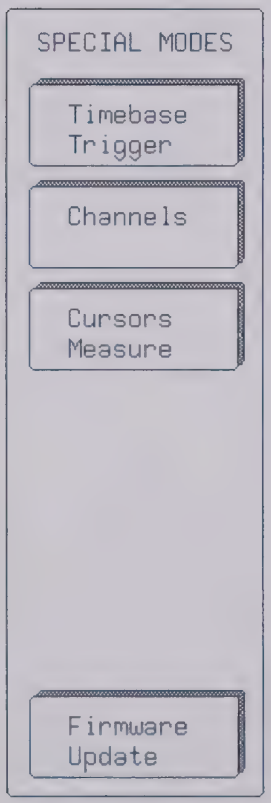
For moving forward to create a space for the insertion of a character.

character

For selecting a character using the menu knob.

Special Modes

SPECIAL MODES — offers access to the primary menus shown here, which in turn access the secondary menus *described immediately below and shown on the following page.*



Timebase Trigger

select to access the secondary menu:

AUTO sequence

For specifying the time-out in Sequence mode using the associated menu knob to change the value.

Channels

Select to access:

On GAIN Changes, all OFFSETS fixed

And the secondary menus:

In

For specifying the offset behavior of a gain (VOLTS/DIV) change. The offset can be fixed either in "Volts" or vertical "Divisions".

Automatic Recalibration

For turning the automatic recalibration "ON" or "OFF". Default is ON. Turning off the auto-recalibration may speed up the acquisition, but during that time calibration is not guaranteed (*see Chapter 3 for details*).

Cursors Measure

Select to access the secondary menu:

Read time cursor amplitudes

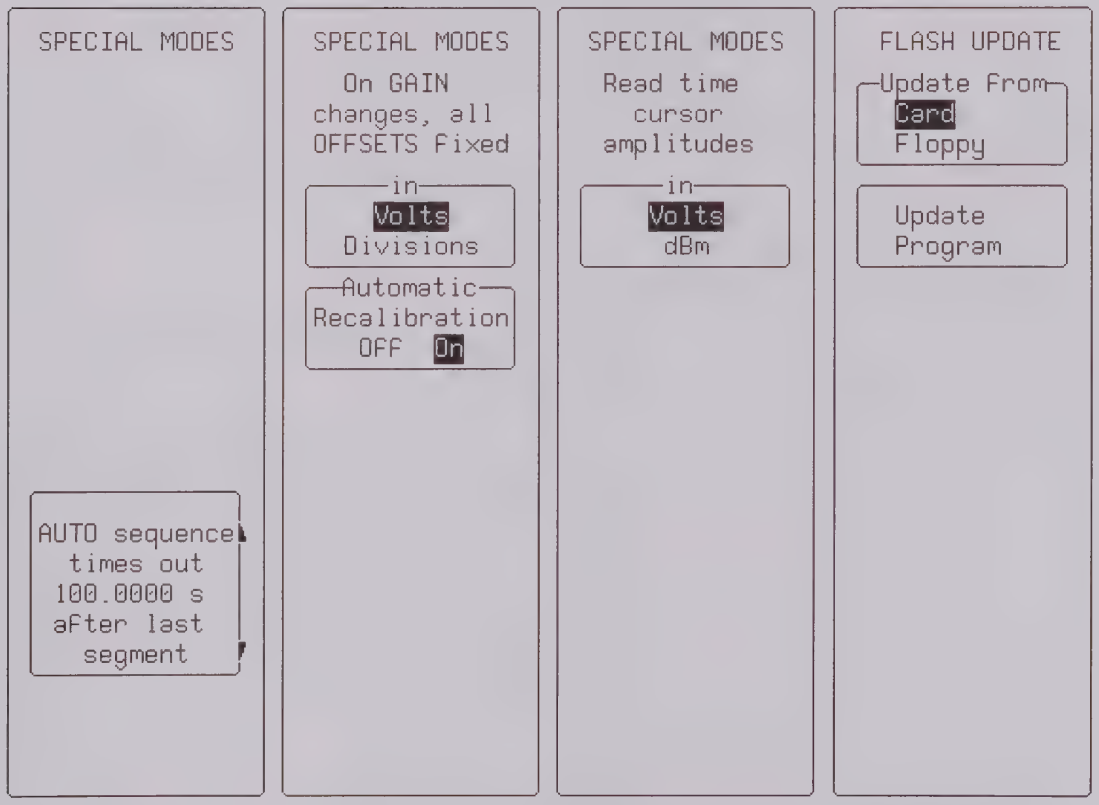
For selecting from "In" the time cursor amplitude units in "Volts" or "dBm".

Firmware Update

Select to access the menu groups (*shown next page*):

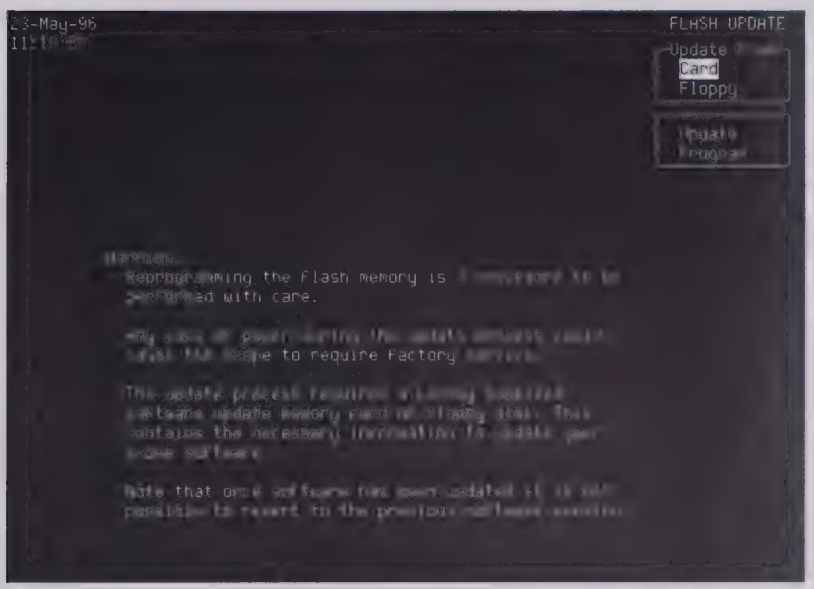
FLASH UPDATE

Offering the secondary menus *shown below right* (*and on 14–21*).



From left to right: Secondary menus accessed with the primary menus "Timebase Trigger", "Channels", "Cursors Measure", and "Firmware Update", respectively.

This page: The full screen warning message shown with "FLASH UPDATE" when "Firmware Update" is selected.



CAL BNC Setup

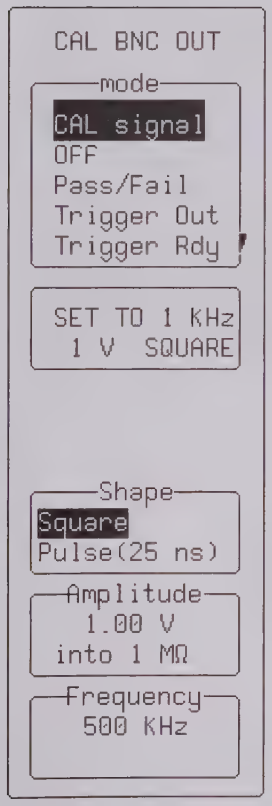
CAL BNC OUT — allows selection of the type of signal put out at the CAL BNC connector and:

- Frequency of the calibration signal
- Amplitude of the calibration signal
- Pulse shape for the calibration signal.

The CAL BNC connector can also be used to provide a pulse:

- As an action for PASS/FAIL testing
- At the occurrence of each accepted trigger event (Trigger Out)
- When the scope is ready to accept a trigger event (Trigger Rdy).

When the instrument is switched on, the calibration signal is automatically set to its default state, 1 kHz 1 V square wave.



mode

To change the kind of signal.

SET TO

To quickly reset the CAL BNC output to its default state.

Shape

To change the form of the calibration signal.

Amplitude

Using the associated knob, for setting the desired high level for all CAL BNC applications. If the BNC output is conncected to an input channel with 50 Ω, the amplitude will be halved.

Frequency

Using the associated knob, for setting the desired frequency of a CAL signal in the range 500 Hz–2 MHz.

Waveform Store

STORE W'FORMS

Press WAVEFORM STORE for:

- Waveform storage, in binary* format only, to internal memory (M1, M2, M3, or M4), when "**Binary**" is selected from the top menu, *as shown here*.
- Waveform storage in either binary or ASCII format, to the optional
  - memory card
  - floppy, or
  - removable hard disk (HDD),

  when "**ASCII**" is selected, *as shown on the next page*. Note, however, that waveforms stored in ASCII *cannot* be recalled back into the scope.
- Auto-Store of waveforms to the memory card or floppy (both optional), and
- Filling the storage medium then stopping the operation ("Fill"). Or using 'wraparound' ("Wrap"), as in a circular buffer, replacing older files with the new ones.

***Note:** The capacity of the Reference and "Zoom & Math" memories each match those of the acquisition memories. For every unit of record length per channel, a point can be stored in any one of the four M reference memories, and the same number of points for each "Zoom & Math" trace. When more acquisition memory is acquired by combining two or four channels, a single long trace can consume all the instrument's Reference memory or "Zoom & Math" trace capacity. If this happens, a warning message will show on-screen to prevent the accidental storage of a new trace to a reference memory already in use.*

* The scope stores data in LeCroy's binary format, conversion of which to ASCII creates an output file requiring 10–20 times the disk space of the original LeCroy binary file. A one-megabyte record will typically take up 13–15 MB stored in ASCII. Furthermore, waveforms stored in ASCII cannot then be recalled back into the scope.

Data Format

For selecting the data format — LeCroy "Binary" or "ASCII". When the latter is selected, the primary "Setup ASCII Format" menu will appear immediately beneath this menu, *as shown next page*. Access is then given to the secondary "ASCII SETUP" menu (*15–3*), from which one of three types of ASCII format can be chosen. This selection will then appear in the "Data Format" menu.

Setup ASCII Format

Appears only when "**ASCII**" is highlighted in "Data Format", as shown this page. For accessing the secondary "ASCII SETUP" menu (*see next page*).

Auto Store

For automatically storing waveforms after each acquisition. "**Fill**" stores until the medium is filled, while "**Wrap**" stores continuously, discarding — first-in–first-out — the oldest files.

DO STORE

To store in accordance with specifications made in the "store" and "to" menus (*see below*).

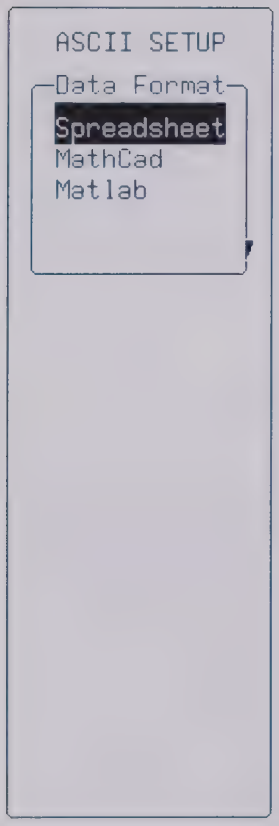
store

For selecting the waveform. "**All displayed**" can only be selected when storing to optional storage media .

to

To select the internal memories "**M1**", "**M2**", "**M3**", or "**M4**", when "Binary is selected in the "Data Format" menu, *as shown on the previous page.*, Or the optional "**Card**", "**Flpy**" or "**HDD**", when "**ASCII**" is selected from the "Data Format" menu, *as shown here.*

ASCII SETUP



Data Format

This secondary menu, accessed through "SETUP ASCII FORMAT" offers a choice of ASCII formats. (*For details on each format, see* Appendix E).

Waveform Recall

RECALL W'FORM — press WAVEFORM RECALL — to recall a waveform from:

- Internal memory
- Memory card (optional)
- Floppy (optional)
- Removable Hard Disk, HDD (optional).

— Memories **(Internal Memory)**

from

To select "**Memories**", for recalling from an internal memory.

DO RECALL

To execute recall based on the selections made in the "from Memory" and "to" menus (*see below*). At the same time resets the horizontal and vertical positions as well as the zooms, showing the full contents of the memory at its original magnification.

from Memory

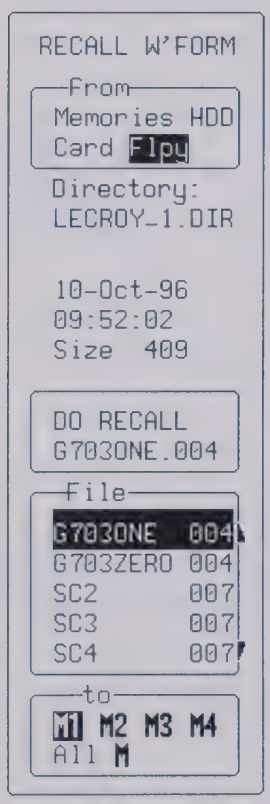
For selecting the source memory.

to

To select the destination trace.

***Note:** Performing a recall operation from an internal memory to Trace A–D overrides any previous definition of the destination trace.*

RECALL W'FORM (Optional Storage Device)



from

Select the device or medium on which the file is stored — "**HDD**", "**Card**", or "**Flpy**".

DO RECALL

To execute recall based on the selections made in the "File" and "to" menus (*see below*).

File

To select the file on which the waveform is stored, using the attributed menu knob.

Note: The files listed will be those in the current working directory.

to

For selecting the destination memory. If the "**All M**" is selected, up to four files with the same three-digit numeric extension as the current "File" selection will be recalled into memories M1–4.

CURSORS: Tools for Measuring Signal Values

Cursors in Standard Display

Cursors are basic tools for measuring signal values.

Amplitude, or Voltage, cursors — broken lines or bars running across the screen — are moved up and down the grid *pixel by pixel.*

Time cursors — arrows or cross-hair markers that move along the waveform (*see symbols*) — can be placed at a desired time to read the amplitude of a signal at that time, and moved to *every single point acquired.*

When a Time cursor is placed on a data point, a cross-bar appears at the tail of the arrow, and at top and bottom of the cross-hair marker.

In Absolute Mode a single cursor is controlled. Readings for amplitude (using Amplitude cursors) or time and amplitude (using Time cursors) can be displayed at the cursor location. Measured amplitudes are relative to ground; measured times to the trigger point.

In Relative Mode, a pair of Amplitude or Time cursors is controlled, providing readings on the difference between the two in amplitude, or time and amplitude, respectively.

Amplitudes are shown in the Trace Label for each trace. When Time cursors are used, the time is shown below the grid. And in Relative Mode the frequency corresponding to the time interval between the cursors is also displayed there.

When there are few data points displayed, Time-cursor positions are linearly interpolated between the data points. Time cursors move up and down along these straight-line segments.

Cursors and Persistence

When using Persistence, Amplitude cursors are as they are in Standard Display (*see above*). Time cursors are vertical bars running down the screen and moving across it.

Cursors in XY Display

In XY Display, Absolute Amplitude cursors are horizontal and vertical bars that can be moved both up and down and from side–to–side across the screen. Relative Amplitude cursors are pairs of bars that move in the same way.

Absolute and Relative Time cursors behave as they do in Standard Display.

Combinations of the amplitude values are shown on the left-hand side of the grid in the following top-to-bottom order:

1. "ΔY value / ΔX value".....Ratio
2. "20 * log 10 (ratio)".....Ratio in dB units
3. "ΔY value * ΔX value".....Product
4. "ϕ = arc tan (ΔY / ΔX)
   range [–180° to +180°]".....Angle (polar)
5. "r = sqrt (ΔX * ΔX + ΔY * ΔY)"....Radius (distance to origin).

The definition of ΔX and ΔY depends on the cursor used. The table below shows how ΔX and ΔY are defined for each type of measurement.

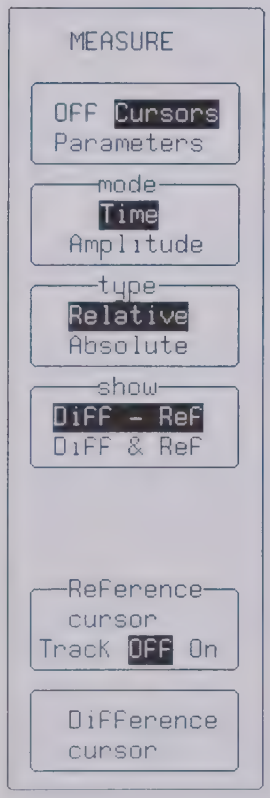
	Cursors				
	A_{Abs}	A_{Rel}	T_{Abs}		T_{Rel}
			Org = (0,0)	Org = $V_{XOffset}$ $V_{YOffset}$	
ΔX	$V_{XRef} - 0$	$V_{XDif} - V_{XRef}$	$V_{XRef} - 0$	$V_{XRef} - V_{XOffset}$	$V_{XDif} - V_{XRef}$
ΔY	$V_{YRef} - 0$	$V_{YDif} - V_{YRef}$	$V_{YRef} - 0$	$V_{YRef} - V_{YOffset}$	$V_{YDif} - V_{YRef}$

Where:

A_{Abs} = *Absolute Amplitude cursors*
A_{Rel} = *Relative Amplitude cursors*
T_{Abs} = *Absolute Time cursors*
T_{Rel} = *Relative Time cursors*
Org = *Origin*
V_{XRef} = *Voltage of the Reference cursor on the X trace*
V_{YRef} = *Voltage of the Reference cursor on the Y trace*
V_{XDif} = *Voltage of the Difference cursor on the X trace*
V_{YDif} = *Voltage of the Difference cursor on the Y trace*

MEASURE — Cursors

Press CURSORS/MEASURE — to access the "MEASURE" Setup menus.



Off/Cursors/Parameters

To select "**Cursors**".

mode

For selecting "**Time**" (time or frequency cursors) or "**Amplitude**" (voltage or amplitude cursors).

type

To toggle between "**Relative**" and "**Absolute**". The first displays two cursors, Reference and Difference, and indicates either the voltage or time and voltage between the two. The second shows a single cursor that indicates either voltage compared to ground level, or this *and* time compared to the trigger point.

show

To select: "**Diff – Ref**", which shows the subtraction between difference- and reference-cursor amplitudes; or "**Diff & Ref**", which displays the amplitude values for each cursor. *Not available in persistence mode.*

Reference cursor

To control the Reference cursor available with Relative cursors, using the associated menu knob. With "Track" "**ON**", both Reference and Difference cursors are controlled by this knob and move together, a constant time or voltage interval maintained between them. This tracking interval is represented by a bar — horizontal for time; vertical for voltage — appearing, respectively, at the top and left-hand edge of the grid.

Difference cursor

For controlling the Difference cursor, available when "**Relative**" is selected from "type" (*see above*), using the associated menu knob.

Cursor position (*not shown*)

For controlling the Absolute cursor, available when "**Absolute**" is selected from "type" (*see above*), using the associated menu knob.

Parameters: Short-Cuts to Signal Properties

Automatic Measurements

The instrument can determine certain signal properties automatically, using signal parameters. The following table lists these parameters, whose statistical variations over several successively captured signals can be observed as average, standard, and extreme deviations. (*See* Appendix D *for the methods employed in determining them.*)

The remainder of the chapter covers the use of Parameters, including in Pass/Fail testing. *A wide range of additional parameters are available in the specialized software packages, such as WP03, described in these packages' operator's manuals.*

Parameter		Description
amplitude	**ampl**	Absolute value of the top minus the base.
area	**area**	Sum of sampled values between cursors times the duration of a sample.
base	**base**	Lower of two most probable states, the higher being **top**. This is characteristic of rectangular waveforms and represents the lower most probable state determined from the statistical distribution of data point values in the waveform.
cycles	**cycles**	Number of pairs of transitions in the same direction.
cyclic mean	**cmean**	Average of data values of an integral number of periods.
cyclic median	**cmedian**	Data value for which 50% of values are above and 50% below.
cyclic root mean square	**crms**	Square root of the sum of squares of the data values divided by the number of points.
cyclic standard deviation	**csdev**	Standard deviation of the data values from the mean value over an integral number of periods.
delay	**delay**	Time from trigger point to the mid-point of the first transition.
Δdelay	**Δdly**	Time between midpoint transition of two sources.

Parameter		Description
Δdelay	Δdly	Time between midpoint transition of two sources.
Δt at level	Δt@lv	Time between able-to-be-selected transition levels of two sources to an able-to-be-selected transition level of one source.
Δclock to data ±	Δc2d±	The difference in time from a clock threshold crossing to either the next (Δc2d+) or previous (Δc2d–) data threshold crossing.
duration	dur	Time from first to last acquisition included in average, histogram or sequence.
duty cycle	duty	Width as a percentage of period.
fall time	fall	Duration of the pulse waveform's falling transition from 90% to 10%, averaged for all falling transitions between the cursors.
fall 80–20%	f80–20%	Duration of the pulse waveform's falling transition from 80% to 20%, averaged for all falling transitions between the cursors.
fall at level	f@level	Duration of the pulse waveform's falling edges between able-to-be-selected transition levels.
first	first	Time from trigger to first (left-most) cursor.
frequency	freq	Reciprocal of period.
last	last	Time from trigger to last (rightmost) cursor.
maximum	maximum	Maximum value of the trace between the cursors.
mean	mean	Average or DC level of the waveform.
median	median	The average of base and top values.
minimum	minimum	Minimum value of the trace between the cursors.
overshoot negative	over–	Lower most probable value minus the minimum sample value, expressed as a percentage of the amplitude.
overshoot positive	over+	Maximum sample value minus the higher most probable value, expressed as a percentage of the amplitude.
peak–to–peak	pkpk	Difference between the maximum and the minimum values.
period	period	Time of a full cycle averaged for all full cycles between the cursors.
phase	phase	Phase difference between signal and reference.
points	points	Number of points between the vertical cursors.
rise time	rise	Duration of the pulse waveform's rising transition from 10% to 90%, averaged for all rising transitions between the cursors.
rise 20–80%	r20–80%	Duration of the pulse waveform's rising transition from 20% to 80%, averaged for all rising transitions between the cursors.

Parameter		Description
rise at level	**r@level**	Duration of the pulse waveform's rising edges between able-to-be-selected transition levels.
root mean square	**rms**	Square root of sum of squares, divided by number of terms.
standard deviation	**sdev**	Square root of sum of squares of difference from mean, divided by number of terms.
time at level	**t@level**	Time from trigger (t=0) to crossing at a specified level.
top	**top**	Higher of two most probable states, the lower being **base**. This is characteristic of rectangular waveforms and represents the higher most probable state determined from the statistical distribution of data point values in the waveform.
width	**width**	Width of the first pulse (either positive or negative), averaged for all similar pulses between the cursors.

MEASURE — Parameters

Parameters can be measured in two standard classes or modes for common measurements on a lone signal in either the amplitude or time domain.

Parameters can also be customized to determine up to five quantities from the parameter list on different signals. Customized parameter measurements can also be used for pass/fail testing against chosen limits.

For all these modes, statistics on the parameter values are accumulated and can be displayed. In addition to the overall number of sweeps used, each parameter has its average, lowest and highest value. The standard deviation of the parameter is also calculated.

Parameter Information and Warning Symbols

The algorithms that determine the pulse waveform parameters are able to detect situations where the mathematical formulas may be applied. However, the results obtained need to be interpreted with caution. In such cases, the name of the parameter and its value are separated on the screen by a graphic symbol. Here are the symbols' meanings:

INFORMATION

Parameter has been determined for several periods (up to 100), and the average of those values has been taken

Parameter has been determined over an integral number of periods

Parameter has been calculated on a histogram

Insufficient data to determine a parameter

WARNINGS

i.e., amplitude histogram is flat within statistical fluctuations. Minimum and maximum are used to assign base and top

Only an upper limit could be estimated (actual value of parameter may be smaller than displayed value)

Signal is partially in overflow

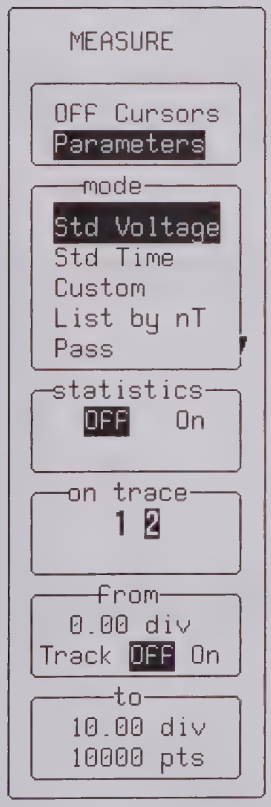
Signal is partially in underflow

Signal is partially in overflow and partially in underflow

MEASURE — Parameters — Standard Voltage

This mode measures, for a single trace:

- Peak–to–Peak (amplitude between maximum and minimum sample values)
- Mean of all sample values (corrected for periodic signals)
- Standard Deviation
- Root Mean Square of all sample values (corrected for periodic signals)
- Amplitude of the signal.



Off/Cursors/Parameters

To select "**Parameters**".

mode

To select "**Standard Voltage**" parameters.

statistics

For turning "**On**" display of the parameter's average, lowest, highest, and standard deviation, as well as the number of sweeps included in the statistics — cleared each time the acquisition conditions change or when the CLEAR SWEEPS button is pressed.

As long as "**Parameters**" is highlighted in the top menu, the accumulation of statistics continues, even if the statistics are not shown.

on trace

To select the trace for which the voltage parameters are measured.

from

To determine the starting point, in screen divisions, for parameter measurements, using the associated menu knob. "Track" "**On**", links control of both the starting and end points of the parameter measurement so that they can be moved together using the associated menu knob.

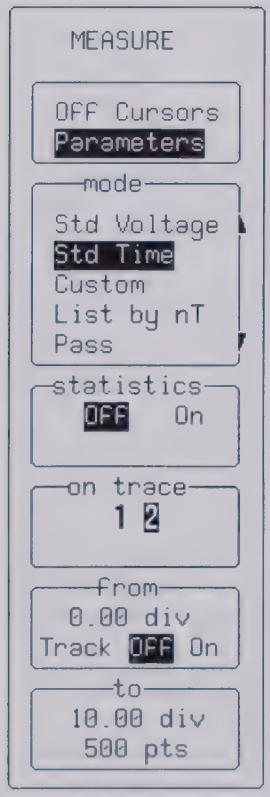
to

To determine the end point in screen divisions. Also indicates the total number of data points used for the measurements.

MEASURE — Parameters — Standard Time

This mode measures for a single trace:

- Period
- Width (at 50% amplitude)
- Risetime (10–90% of amplitude)
- Falltime (90–10% of amplitude)
- Delay (from trigger to first 50% amplitude point).



Off/Cursors/Parameters

To select "**Parameters**".

mode

For selecting "**Standard Time**" parameters.

statistics

For turning "**On**" display of the parameter's average, lowest, highest, and standard deviation, as well as the number of sweeps included in the statistics — cleared each time the acquisition conditions change or when the CLEAR SWEEPS button is pressed.

As long as "**Parameters**" is highlighted in the top menu, the accumulation of statistics continues, even if the statistics are not shown.

on trace

For selecting the trace for which the time parameters are to be measured.

from

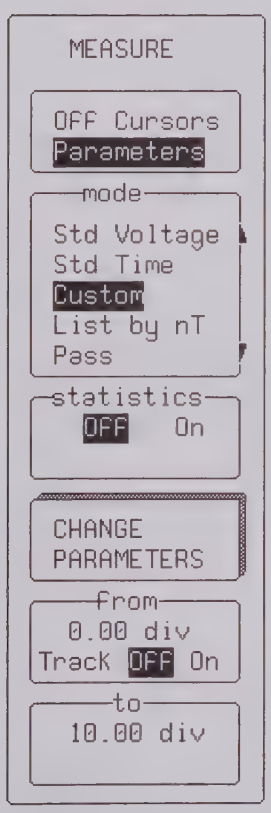
To determine the starting point, in screen divisions, for parameter measurements. "Track" "**On**", links control of both the starting and end points of the parameter measurement so that they can be moved together using the associated menu knob.

to

To determine the end point in screen divisions. Also indicates the total number of data points used for the measurements.

MEASURE — Parameters — Custom

In this mode, up to five parameters can be displayed for various traces.



Off/Cursors/Parameters

For selecting "**Parameters**".

mode

To select "**Custom**" parameters.

statistics

For turning "**On**" display of the parameter's average, lowest, highest, and standard deviation, as well as the number of sweeps included in the statistics — cleared each time the acquisition conditions change or when the CLEAR SWEEPS button is pressed.

As long as "**Parameters**" is highlighted in the top menu, the accumulation of statistics continues, even if the statistics are not shown.

CHANGE PARAMETERS

For accessing the secondary "CHANGE PARAM" menu (*see following pages*).

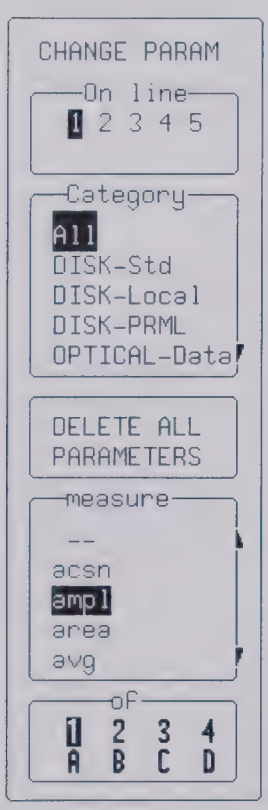
from

To determine the starting point, in screen divisions, for parameter measurements. "Track" "**On**", links control of both the starting and end points of the parameter measurement so that they can be moved together using the associated menu knob.

to

To determine the end point in screen divisions.

CHANGE PARAM — for modifying parameters.



On line

To select for modification up to five different parameters, "**1**", "**2**", "**3**", "**4**", or "**5**".

Category

To specify the category of parameter. When "**All**" is selected, the "measure" menu (see below) will feature all parameters. However, when a particular category is selected, only those parameters in the category are shown.

DELETE ALL PARAMETERS

For deleting all parameters previously selected.

measure

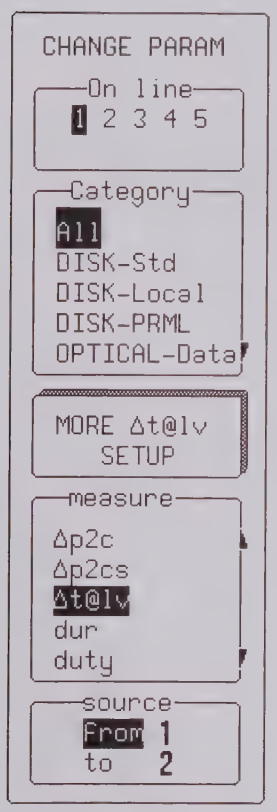
To choose the new parameter to be measured on this line. When "– –" is selected the line is not used.

of

For selecting the trace on which the parameter will be measured.

CHANGE PARAM

Parameters can be customized to meet specific needs:



On line

To select for modification up to five different parameters, "**1**", "**2**", "**3**", "**4**", or "**5**".

Category

To specify the category or type of parameter.

MORE Δt@lv SETUP

Calls up the"**Δt@lv**" customization menu (*next page*).

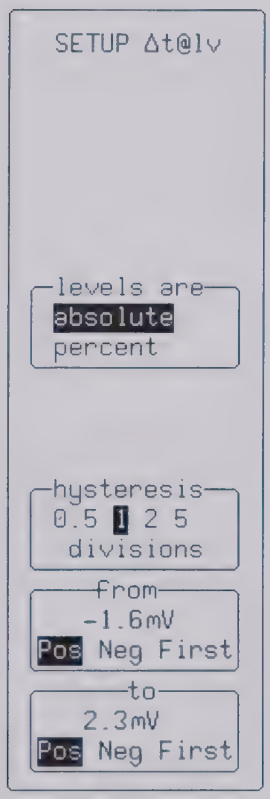
measure

Set at **Δt@lv**.

source

Using the menu button, selects the channel ("**1**", "**2**", "**3**" or "**4**") or memory ("**A**", "**B**", "**C**", or "**D**"). And with the knob, selects "**from**" which and "**to**" which channel the measurement is to be made.

SETUP "Δt@lv" — for customizing the Δt@lv parameter.



levels are

For selecting whether the levels should be set in absolute or percentage of the peak–to–peak signal value.

hysteresis

To set the hysteresis division. Hysteresis essentially enables the user to set a voltage band, which a waveform peak–trough pair must exceed in order not be considered either noise or a "bump". This threshold crossing is recognized when an acquisition point in the waveform passes through the threshold level by 1/2 the hysteresis-division setting.

from

For selecting the voltage setting: the level on the trace at which the timing should start. And to select *where* the timing should start: "**Pos**" for rising edge, "**Neg**" for falling edge, "**First**" for either positive or negative edges.

to

For selecting the voltage setting: the level on the trace at which the timing should finish. And to select *where* the timing should finish: "**Pos**" for rising edge, "**Neg**" for falling edge, "**First**" for either positive or negative edges.

SETUP "**Δc2d+**" — for customizing the Δc2d+ parameter.

hysteresis

To set the hysteresis division. Hysteresis essentially enables the user to set a voltage band, which a waveform peak–trough pair must exceed in order not be considered either noise or a "bump". This threshold crossing is recognized when an acquisition point in the waveform passes through the threshold level by 1/2 the hysteresis-division setting.

clock edge

To select the clock edge or edges used for this parameter measurement.

data edge

For selecting the data edge or edges used for the measurement.

PASS/FAIL Testing

The parameters tabled in this chapter can also be used in carrying out Pass/Fail tests. Tests require a combination of measurements within chosen limits, with an action provoked when the test either passes or fails, depending on which has been specified. Signals can also be Pass/Fail tested against a tolerance mask.

Up to five parameters can be tested against limits at the same time. And, in tolerance mask testing, a trace can be compared to a tolerance mask.

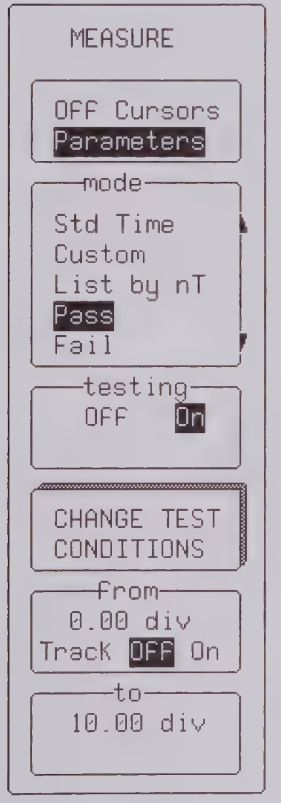
Whether the tests pass or fail, any or all of the following actions can be provoked:

- Stop capturing further signals
- Dump the screen image to a hardcopy unit
- Store selected traces to internal memory, to a memory card (optional), or to a floppy (optional)
- Sound the buzzer
- Emit a pulse on the CAL BNC.

The Pass/Fail display will show:

- Results on the current waveforms
- Number of events passing
- Total number of sweeps treated
- Actions to be taken.

MEASURE — Parameters — Pass/Fail



Off/Cursors/Parameters

To select "**Parameters**".

mode

To select "**Pass**" or "**Fail**".

testing

For turning testing "**Off**" or "**On**". Testing is turned off in order to observe only the parameter variations.

CHANGE TEST CONDITIONS

To access the secondary "CHANGE TEST" menu (*see next page)*

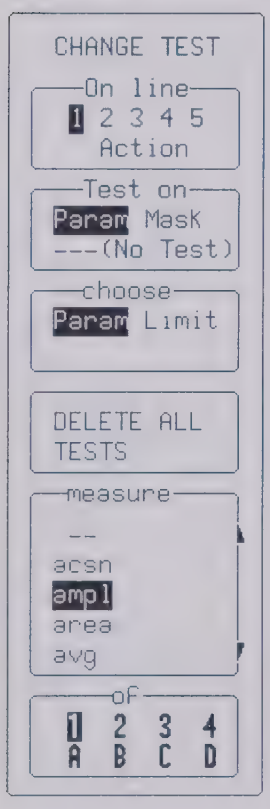
from

To determine the starting point, in screen divisions, for parameter measurements.

to

To determine the end point in screen divisions.

CHANGE TEST



On line

To select for modification up to five different parameters, "**1**, **2**, **3**, **4** or **5**"

Test on

To select "**Param**" or, if no test is required, "**--- (No Test)**".

choose

To select "**Param**".

DELETE ALL TESTS

For deleting all tests previously selected.

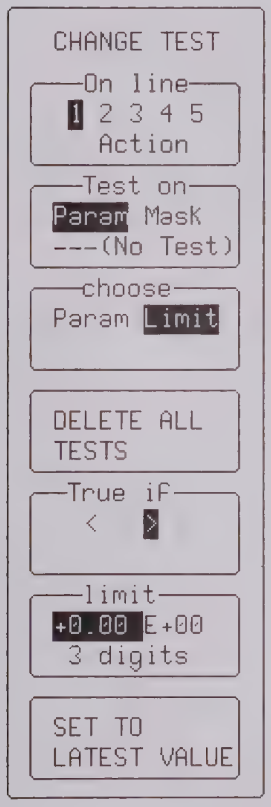
measure

For selecting the new parameter to be measured on this line. When "**--**" is selected the line is not used.

of

For selecting the trace on which the parameter will be measured.

CHANGE TEST — Param (Changing Limits for Pass/Fail Tests on Parameters)



On line

To select for modification up to five different parameters, "**1**, **2**, **3**, **4** or **5**"

Test on

To Select "**Param**" or "**--- (No Test)**" if no test required on the selected line (*"Mask" selection, page 16–19*).

choose

For setting to "**Limit**" (*"Param" 16–17*).

DELETE ALL TESTS

For deleting all tests previously selected.

True if

For selecting the adequate relation — smaller than "**<**" , or greater than "**>**".

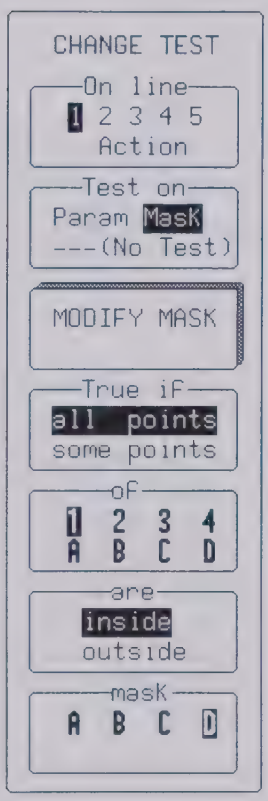
limit

To make the choice of one of three modifications of a limit: its mantissa, exponent, and the number of digits for the representation of its mantissa. The corresponding menu button is used to select, and the associated knob to modify the number in that field.

SET TO LATEST VALUE

To set the limit to the latest measured value — a starting value for the final adjustment.

CHANGE TEST — Mask (Changing Pass/Fail Test on a Mask)



On line

To select for modification up to five different parameters, "**1**, **2**, **3**, **4** or **5**" (*"Action" selection, page 16–22).*

Test on

For setting to "**Mask**" or "**— (No Test)**" if no test required on the selected line (*"Param" 16–17*).

MODIFY MASK

To access the secondary menu for modifying mask settings.

True if

For choosing this mask-test condition.

of

To select trace for testing.

are

For choosing this mask-test condition.

mask

To select mask trace "**A**", "**B**", "**C**" or "**D**".

Note: *Pass/Fail testing against a mask is affected by horizontal and vertical zooming of the mask trace. The test will be made inside the area bordered by the parameter cursors.*

Timebases of the mask and the trace under test should be identical.

For visual mask testing, a single-grid display should be used when performing a single-trace mask test, while a dual-grid display should be used for a dual-trace test.

MODIFY MASK — W'form (Generating a Mask from a Waveform)

from

To select "**W'form**".

into

For selecting "**D=M4**" if the mask is to be automatically displayed on the screen Otherwise select "**M1**", "**M2**", "**M3**", or "**M4**".

Using "RECALL W'FORM" (*see previous chapter*) memories M1–M4 can be recalled to traces A to D for display.

INVERT MASK

To generate an inverted mask.

Use W'form

For selecting the waveform to be used as reference. The mask will be generated around this waveform.

MAKE MASK

To generate the mask.

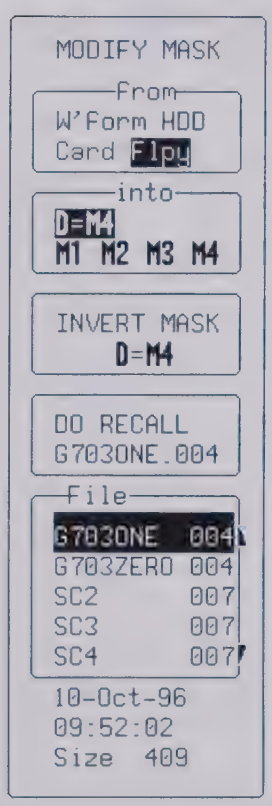
delta V

For selecting tolerance in amplitude, using the attributed knob.

delta T

For selecting tolerance in time, using the attributed menu knob.

MODIFY MASK — (Recalling a Mask from a Mass Storage Device)* — Flpy



from

To select the device.

into

For selecting "**D=M4**" to automatically display the mask on- screen, or "**M1**", "**M2**", "**M3**" or "**M4**".

INVERT MASK

For generating an inverted mask.

DO RECALL

To recall the mask.

File

To select the appropriate mask, using the associated menu knob.

* Depending on options installed. Floppy disk used here as an example.

CHANGE TEST — Action (Setting PASS/FAIL Actions)

Depending on the test result certain actions can be taken.

On line

For selecting "**Action**".

DELETE ALL ACTIONS

To delete all previously selected actions.

If

To determine if the action will be taken on "**PASS**" or "**FAIL**".

Then:

For selecting the action.

Dump:

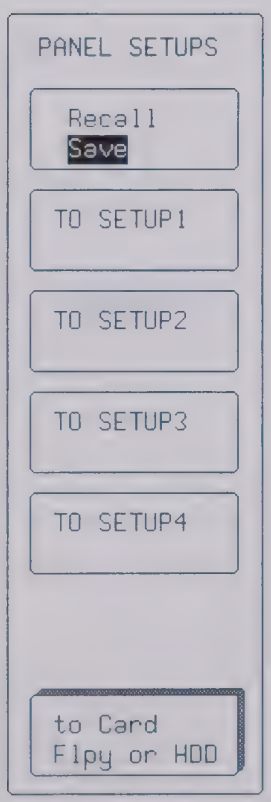
To enable or disable the action.

Saving and Recalling Panel Setups

PANEL SETUPS

PANEL SETUPS

Press PANEL SETUPS **to access menus for saving or recalling configurations, or panel setups, to non-volatile memory, memory card, floppy or hard disk, depending on the options installed.**



Recall or **Save**

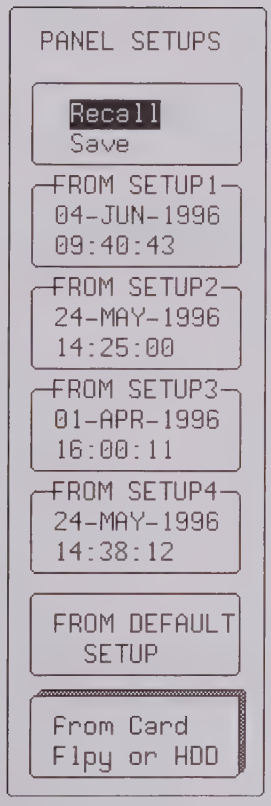
To select "**Recall**" or "**Save**".

TO SETUP 1 ...**2** ...**3** or ...**4**

To select one of the four setups.

to Card, Flpy or HDD

For saving the setup to memory card, floppy or hard disk (*see page 17–3*).



Recall or Save

Select "**Recall**" and these menus appear:

FROM SETUP 1 ...**2** ...**3** or ...**4**

To select the setup.

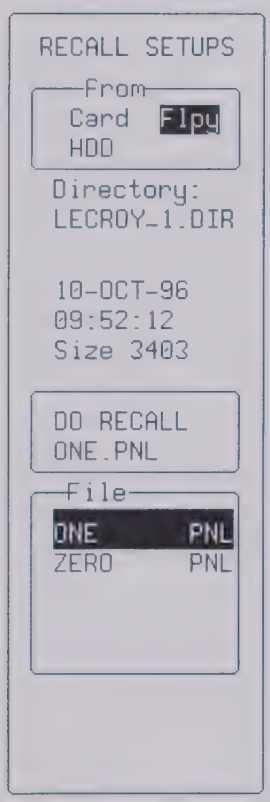
FROM DEFAULT SETUP

To select a default setup.

from Card, Flpy or HDD

For accessing the secondary "RECALL SETUPS" menu to recall a setup stored on card, floppy, or hard disk.

RECALL SETUPS (Recalling a Setup from Card, Floppy, or Hard Disk)



from

For selecting "**Card**", "**Flpy**" or "**HDD**".

DO RECALL

To perform the recall of the setup selected in the "File" menu

File

For selecting the stored setup, using the attributed menu knob.

The Complete Picture — Summarized

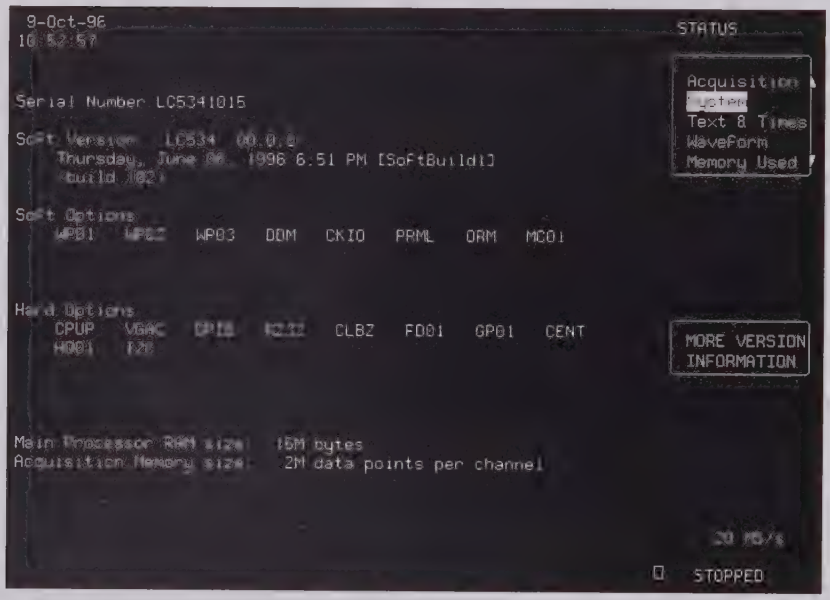
STATUS — press SHOW STATUS — to obtain full-screen summaries of:

- Acquisition
- System
- Waveform text and trigger times
- Waveforms
- Memory used.

Acquisition Summary Vertical sensitivity, probe attenuation, offset and coupling for each channel, then timebase-, trigger- and delay-status summaries.

System Summary

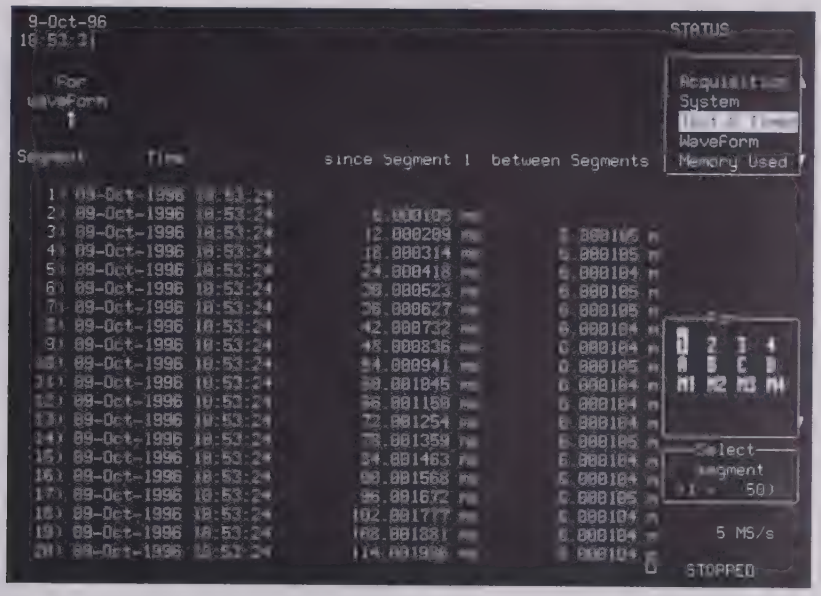
Scope serial number, firmware version, and software and hardware options installed.



The "MORE VERSION INFORMATION" menu is used to perform a cyclic redundancy check (CRC) of the internal firmware and will generate a checksum that can be used to ensure the firmware is uncorrupted.

Text & Times Summary

User text in the waveform descriptor (see *Remote Control Manual*), and trigger timing information.



Waveform Summary

Detailed status information on channels, memories, zoom + math or displayed traces, chosen from the bottom menu.

Memory Used Summary Memory allocation — memories M1–4 can be cleared using this menu.

The dedicated persistence data maps for each channel are dynamically created, resized and deleted as necessary. The allocation of memory to each of these data maps will appear in this menu. Persistence data maps are cleared using the CLEAR SWEEPS button.

Signal Capture

Acquisition System

LC334A / LC374A Bandwidth (–3 dB): @ 50 Ω: DC to 500 MHz
100 mV/div: 400 MHz; 5–50 mV/div: 350 MHz.

LC534A / LC574A Bandwidth (–3 dB): @ 50 Ω: DC to 1 GHz
10 mV/div and above.

LC334A / LC374A / LC534A / LC574A Bandwidth (3 dB): @ 1 MΩ DC: DC to 500 MHz typical at probe tip with optional 1 GHz FET probe for LC334A, and with PP005 supplied as standard for LC374A / LC534A / LC574A.

No. of Channels: Four.

No. of Digitizers: Four.

Max. Sample Rate Window LC334A / LC534A: 4 ms @ 2 GS/s in single-shot mode.

Max. Sample Rate Window LC374A: 0.25 ms @ 2 GS/s in single-shot mode.

Max. Sample Rate Window LC574A: 2 ms @ 4 GS/s in single-shot mode.

Sensitivity LC334A:
2 mV/div to 5 V/div, 50 Ω, fully variable.
2 mV/div to 5 V/div, 1 MΩ, fully variable.

Sensitivity LC374A / LC534A / LC574A:
2 mV/div to 1 V/div, 50 Ω, fully variable.
2 mV/div to 10 V/div, 1 MΩ, fully variable.

Scale Factors: A wide selection of probe attenuation factors.

Offset Range LC334A:
2.00–9.99 mV/div: ±120 mV
10.0–199 mV/div: ±1.2 V
0.2–5.0 V/div: ±24 V.

Offset Range LC374A / LC534A / LC574A:
2.00–4.99 mV/div: ±400 mV
5.00–99 mV/div: ±1 V
0.1–1.0 V/div: ±10 V
1.0–10 V/div: ± 100 V (1 MΩ only).

DC Accuracy: 1 % typical; guaranteed ≤ ±2 % full scale (eight divisions) at 0 V offset.

Vertical Resolution: 8 bits.

Bandwidth Limiter LC334A: 30 MHz

Bandwidth Limiter LC374A / LC534A / LC574A: 25 MHz, 200 MHz.

Input Coupling: AC, DC, GND.

Input Impedance: 10 MΩ//15 pF for LC334A (system capacitance using PP005), 10 MΩ//11 pF for LC374A / LC534A / LC574A (system capacitance using PP005), or 50 Ω ±1 %.

Max. Input LC334A / LC374A / LC534A / LC574A:
50 Ω: ±5 V DC (500 mW) or 5 V rms
1 MΩ — LC334A: 250 V max (DC + peak AC ≤10 kHz)
1 MΩ — LC374A / LC534A / LC574A: 400 V max (DC + peak AC ≤10 kHz).

SMARTMemory: Total memory management system, dynamically manages acquisition memory to guarantee signals are always sampled at the highest possible sample rate and system RAM and microprocessor resources always optimally employed.

Channel Use	Maximum Sampling Rate			Memory per Channel			Active Channels
	LC334A LC534A	LC374A✓	LC574A	LC334A LC374A LC534A LC574A	LC334AM LC534AM LC574AM	LC334AL LC534AL LC574AL	
All Peak Detect OFF	500 MS/s	1 GS/s	1 GS/s	100 k	500 k	2 M	All
Paired Peak Detect OFF	1 GS/s	2 GS/s	2 GS/s	250 k	1 M	4 M	CH 2 & CH 3
Paired + Adapter Peak Detect OFF	2 GS/s	2 GS/s✓✓	4 GS/s	500 k	2 M	8 M	One
All Peak Detect ON	100 MS/s data + 400 MS/s peaks			50 k data + 50 k peaks	250 k data + 250 k peaks	1 M data + 1 M peaks	All

✓ No external adapter
✓✓ On CH 2

Acquisition Modes

Random Interleaved Sampling (RIS): For repetitive signals from 1 ns/div to 5 µs/div (LC334A / LC534A), or 1 ns/div to 2 µs/div (LC374A / LC574A).

Single Shot: For transient and repetitive signals from 10 ns/div (LC334A / LC534A), or 1 ns/div (LC374A / LC574A), all channels active.

Peak Detect: At 400 MS/s, peak detect can capture high-speed events down to 1 ns, while simultaneously capturing normally sampled data. Note: With a resolution of 2.5 ns there is no guarantee that all high-speed events less than 2.5 ns in duration will be captured with peak detect.

Sequence: Stores multiple events, each time-stamped, in segmented acquisition memories.

Dead Time between Segments: Typically < 30 µs, max. 50 µs.

Models				Segments
LC334A	LC374A	LC534A	LC574A	500
LC334AM	LC534AM		LC574AM	2000
LC334AL	LC534AL		LC574AL	

Timebase System

Timebases: Main and up to four Zoom Traces.

Time/Div Range: 1 ns/div to 1000 s/div.

Clock Accuracy: ≤10 ppm.

Interpolator resolution: 10 ps.

Roll Mode: Ranges 500 ms–1000 s/div.
For > 50 000 points: 10–1000 s/div.

External Clock: ≤100 MHz (20–100 MHz for LC374A and LC574A) on EXT input with ECL, TTL or zero crossing levels. Optional 50–500 MHz rear-panel fixed frequency clock input.

External Reference: Optional 10 MHz rear-panel input.

Triggering System

Modes: Normal, Auto, Single, and Stop.

Sources: CH1, CH2, CH3, CH4, Line, Ext, Ext/10. Slope, Level and Coupling are unique to each source.

Slope: Positive, Negative.

Coupling: AC, DC, HF, LFREJ, HFREJ.

Pre-trigger Recording: 0–100 % of full scale (adjustable in 1 % increments).

Post-trigger Delay: 0–10 000 divisions (adjustable in 0.1 div increments).

Holdoff by Time: 10 ns–20 s.

Holdoff by Events: 0–99 999 999.

Internal Trigger Range: ±5 div.

EXT Trigger Max Input LC334A:

10 MΩ/15 pF (LC334A system capacitance using PP002): 250 V max. (DC + peak AC ≤10 kHz)
50 Ω ±1 %: ±5 V DC (500 mW) or 5 V rms.

EXT Trigger Max Input LC374A / LC534A / LC574A:

10 MΩ/11 pF (system capacitance using PP005): 400 V (DC + peak AC ≤10 kHz) 50 Ω ±1 %: ±5 V DC (500 mW) or 5 V rms.

EXT Trigger Range: ±0.5 V (±5 V with Ext/10).

Trigger Timing: Trigger Date and Time are listed in the "Memory Status" Menu.

Trigger Comparator: Optional ECL rear panel output. Alternatively, the calibrator output can provide a trigger output or a PASS/FAIL test output.

SMART Trigger Types

Pattern: Trigger on the logic combination of five inputs — CH1, CH2, CH3, CH4, and EXT Trigger, where each source can be defined as "High", "Low" or "Don't Care". The Trigger can be defined as the beginning or end of the specified pattern.

Signal or Pattern Width: Trigger on width between two limits able to be selected from 2.5 ns to 20 s. Will typically trigger on glitches 1 ns wide.

Signal or Pattern Interval: Trigger on interval between two limits able to be selected from 10 ns to 20 s.

Dropout: Trigger if the input signal drops out for longer than a time-out from 25 ns to 20 s.

State/Edge Qualified: Trigger on any source only if a given state (or transition) has occurred on another source. The delay between these events can be defined as a number of events on the trigger channel or as a time interval.

TV: Allows selection of both line (up to 1500) and field number (up to 8) for PAL, SECAM, NTSC or nonstandard video.

Exclusion Trigger: Trigger on intermittent faults by specifying the normal width or period of a signal. The oscilloscope will trigger only on aberrations which are shorter or longer than normal.

Autosetup

Pressing AUTOSETUP sets timebase, trigger and sensitivity to display a wide range of repetitive signals. (Frequency above 50 Hz; Duty Cycle greater than 0.1 %).

Autosetup Time: Approximately two seconds.

Vertical Find: Automatically sets sensitivity and offset for selected channel.

Probes

LC334A: One PP005 probe is supplied per channel. DC to 350 MHz typical at probe tip, 500 V max.

LC374A / LC534A / LC574A: One PP005 probe is supplied per channel. DC to 500 MHz typical at probe tip, 500 V max.

Probe calibration: Max 1 V into 1 MΩ, 500 mV into 50 Ω, frequency and amplitude able to be programmed, pulse or square wave able to be selected, rise and fall time 1 ns typical.

<table>
<tr><th colspan="4">Models</th><th>System RAM (Mbytes)</th></tr>
<tr><td>LC334A</td><td>LC374A</td><td>LC534A</td><td>LC574A</td><td rowspan="2">8</td></tr>
<tr><td>LC334AM</td><td colspan="2">LC534AM</td><td>LC574AM</td></tr>
<tr><td colspan="2">LC334AL</td><td colspan="2">LC534AL</td><td>16</td></tr>
<tr><td colspan="4">LC574AL</td><td>64</td></tr>
</table>

Signal Viewing

Display

Screen Type: Color 10-inch Raster Scan CRT, 0.26 mm dot pitch.

Resolution: 640 x 480 points.

Display Area: 170 mm x 125 mm — 50 % greater than that of a 7-inch display.

Controls: Rear-panel presets for position, brightness and contrast. Front-panel menu controls for brightness and color selection.

Grid Styles: Single, Dual, Quad, XY, Single+XY, Dual+XY, and Full Screen — an enlarged view of each grid style.

Graticules: Internally generated; separate intensity control for grids and waveforms. Selectable blending of grid with displayed traces.

Waveform Style: Dot Join with optional sample point highlight or Dots only.

Persistence Modes: Color Graded and Analog Persistence™, infinite or variable with decay over time. In Color Graded persistence a color spectrum from red through violet is used to map signal intensity. With Analog Persistence the brightness level of a single color denotes signal intensity. Each trace's persistence data is stored in 64 000 levels. On LC334A models, Analog Persistence is only available in four-channel mode.

Trace Display: Opaque or transparent mode, with overlap management.

Number of Traces: Four (any mix of channels, memories or Math functions).

Real-time Clock: Date, hours, minutes, seconds.

External Monitor: Rear-panel 15-pin socket for VGA compatible monitor.

Vertical Zoom: Up to five times vertical expansion (50 times with averaging, up to 40 µV/div sensitivity).

Horizontal Zoom — LC334A / LC534A: Waveforms can be expanded to give 2–2.5 points/division. This allows zoom factors of up to 100 000 times for the M models and up to 400 000 times for the L models when channels are combined.

Horizontal Zoom — LC374A / LC574A: Waveforms can be expanded to give 0.4–0.5 points/division, allowing zoom factors of up to 2 million times for the LC574AL when all channels are combined.

Models				Zoom Factors
LC334A	LC534A			2000 x
LC334AM	LC374A	LC534AM	LC574A	20 000 x
LC334AL	LC534AL	LC574AM		100 000 x
LC574AL				400 000 x

Signal Analysis

A comprehensive and easy-to-use set of diagnostic tools are available. Calculations are performed rapidly and results can be presented on-screen or stored to disk.

Rapid Processing System

Microprocessor: 96 MHz PowerPC™ 603e.

System RAM: 8–64 Mbytes.

Video Memory: 1 Mbyte.

Cache Memory: 32 kbytes.

Persistence Data Map Memory: 16 bits per displayed pixel (64 000 levels).

Waveform Processing

Up to four processing functions may be performed simultaneously. Standard functions available are: Add, Subtract, Multiply, Divide, Negate, Identity, Summation Averaging and Sine x/x. The source information for a math function trace can be data from an acquisition channel or from another math function trace. This allows display of traces which 'daisy chain' math functions.

Average: Up to 10^6 averages are possible.

Extrema: Roof, Floor, or Envelope values from 1 to 10^6 sweeps.

ERES: Six Low-Pass digital filters provide up to 11-bit vertical resolution. Sampled data is always available, even when a trace is turned off.

FFT: Spectrum Analysis with five windowing functions and FFT averaging.

Statistical Diagnostics: The Parameter Analysis package permits in-depth diagnostics on waveform parameters. Live histogramming of any waveform parameter measurement is possible and the histogram can be autoscaled to display the center and width of the distribution. Any of the above processes can be invoked without losing the data.

Internal Memory

Waveform Memory: Up to four 16-bit Memories (M1, M2, M3, M4), whose length corresponds to the length of the channel acquisition memory.

Zoom & Math Memory: Up to four 16-bit Waveform Processing Memories (A, B, C, D), whose length corresponds to the length of the channel acquisition memory.

Setup Memory: Four non-volatile memories. Optional Memory Cards, Flash Disks or removable Hard Disks may also be used for high-capacity waveform and setup storage.

Cursor Measurements

Relative Time: A pair of arrow cursors measure time differences and voltage differences relative to each other.

Relative Voltage: A pair of line cursors measure voltage differences.

Absolute Time: A cross-hair marker measures time relative to the trigger, and voltage with respect to ground.

Absolute Voltage: A reference bar measures voltage with respect to ground.

Automated Measurements A wide range of pulse parameter measurements are available. These are categorized for ease of use. The categories include Pulse, Horizontal, and Vertical parameters. Basic statistical measurements, included as standard, (average, highest, lowest, and standard deviation) can be made on these parameter measurements in order to understand their distribution. Pass/Fail Testing and Waveform Limit testing using masks can be performed. Test conditions can be expressed as either waveform parameter limits, waveform shape limits (mask) or a combination of both. Any failure can cause preprogrammed actions such as Hardcopy, Save, GPIB service request, logic pulse out, audible beep, or any combination of the above.

Additional Information

Interfacing

Remote Control: Possible by GPIB and RS-232-C for all front-panel controls, as well as all internal functions.

RS-232-C Port: Asynchronous up to 19.2 kbytes/s for computer/terminal control or printer/plotter connection.

GPIB Port: (IEEE-488.1) Configurable as talker/listener for computer control and fast data transfer, up to 300 kbytes/s. Command Language complies with requirements of IEEE-488.2.

Centronics Port: Hardcopy parallel interface.

PC Card (PCMCIA II/III Ports): For memory cards, flash cards and removable hard disks.

Floppy Disk: High density 3.5-inch floppy disk drive (DOS format).

VGA Compatible Display: 15-pin D-type VGA compatible connector for external color display.

Hardcopy: Screen dumps are activated by a front-panel button or via remote control. TIFF and BMP formats are available for importing to Desktop Publishing programs. The following printers and plotters can be used to make hardcopies:

B/W: HP LaserJet™, HP DeskJet™ 500, Epson™ FX **Color:** HP DeskJet 550C, Epson Stylus.

An optional (standard on all LC574A models) internal high-resolution graphics printer is also available for screen dumps; a stripchart output format with two meters per division is also possible.

Output Formats: ASCII waveform output is available, compatible with spreadsheets, MATLAB™, MathCad™. Binary output is also available.

General

Auto-calibration: Ensures specified DC and timing accuracy.

Temperature: 5 to 40 °C (41 to 104 °F) rated.

Humidity: 80 % for temperatures up to 31 °C, decreasing linearly to 50 % relative humidity at 40 °C.

Altitude: Up to 2000 m (6560 ft) operating, 40 °C max.

Power: 90–132 V AC, 180–250 V AC, 45–66 Hz, 400 W.

Battery Backup: Front-panel settings maintained for two years.

Dimensions: (HWD) 10.4 x 15.65x 17.85 inches / 264 x 397 x 453 mm.

Weight: 20 kg (44 lb.) net, 28 kg (61.6 lb.) shipping.

Warranty: Three years.

CE Approval

EMC: Conforms to EN 50081-1, EN 50082-1. *See* Declaration of Conformity *for details.*

Safety: The oscilloscope has been designed to comply with EN 61010-1, Installation (Over-voltage) Category II, Pollution Degree 2.

Enhanced Resolution Filtering

The available sampling rate of LeCroy oscilloscopes is often higher than that required for the analyzed signal's bandwidth. This oversampling, pronounced in the long-memory scopes, can be used to increase the displayed trace's effective resolution: the ability of the instrument to distinguish closely spaced voltage levels. It is done by filtering the digitized signal.

Although similar to signal smoothing using a simple moving-average filter, enhanced resolution filtering is more efficient both in terms of bandwidth and the superior passband characteristics that result. And on waveforms with single-shot characteristics, it can be used instead of successive trace averaging.

Advantages

Enhanced resolution filtering improves two of the instruments important characteristics — each subtly different from the other:

1. Resolution is improved by a fixed amount for each filter. This true increase in resolution occurs whether or not the signal is noisy, or whether a single-shot or repetitive signal.
2. Signal-to-noise ratio (SNR) is improved in such a way as to be dependent on the form of the noise in the original signal. This is because the enhanced resolution filtering decreases the bandwidth of the signal, therefore filtering out some of the noise.

Implementation

The oscilloscope's set of constant-phase, finite impulse-response (FIR) filters provide fast computation, excellent step response and minimum bandwidth reduction for resolution improvements of between 0.5 and 3 bits in 0.5 bit steps. Each step corresponds to a bandwidth reduction of a factor of two, allowing easy control of the bandwidth/resolution trade-off. The parameters of the six filters are given in the following table:

Parameters of the FIR Enhanced Resolution Filters		
Resolution Increase (Enhancement)	**–3 dB Bandwidth (× Nyquist)**	**Filter Length (samples)**
0.5	0.5	2
1.0	0.241	5
1.5	0.121	10
2.0	0.058	24
2.5	0.029	51
3.0	0.016	117

With low-pass filters, the actual SNR increase obtained in any particular situation depends on the power spectral density of the noise on the signal. The improvement in SNR corresponds to the improvement in resolution if the noise in the signal is white — that is, if it is evenly distributed across the frequency spectrum. If the noise power is biased towards high frequencies, the SNR improvement will be better than the resolution improvement. Whereas the opposite may be true if the noise is mostly at lower frequencies.

SNR improvement due to the removal of coherent noise signals — feed-through of clock signals, for example — is decided by the fall of the dominant frequency components of the signal in the passband. This is easily ascertained using the Spectrum Analysis option (WP02).

The filters have a precisely constant zero phase response. This has two desirable properties. First, the filters do not distort the relative position of different events in the waveform, even if the events' frequency content is different. And second, because the waveforms are stored, the delay normally associated with filtering (between the input and output waveforms) can be exactly compensated during the computation of the filtered waveform.

All the filters have been given exact unity gain at low frequency. Enhanced resolution should thus not cause overflow if the source data is not overflowed. If part of the source trace were to overflow, filtering will be allowed, but the results in the vicinity of the overflowed data — the filter impulse response length — will be incorrect. This so because in some circumstances an overflow may be a spike of only one or two samples, and the energy in this spike may not be enough to significantly affect the results. It would then not be desirable to disallow the whole trace.

When to Use It?

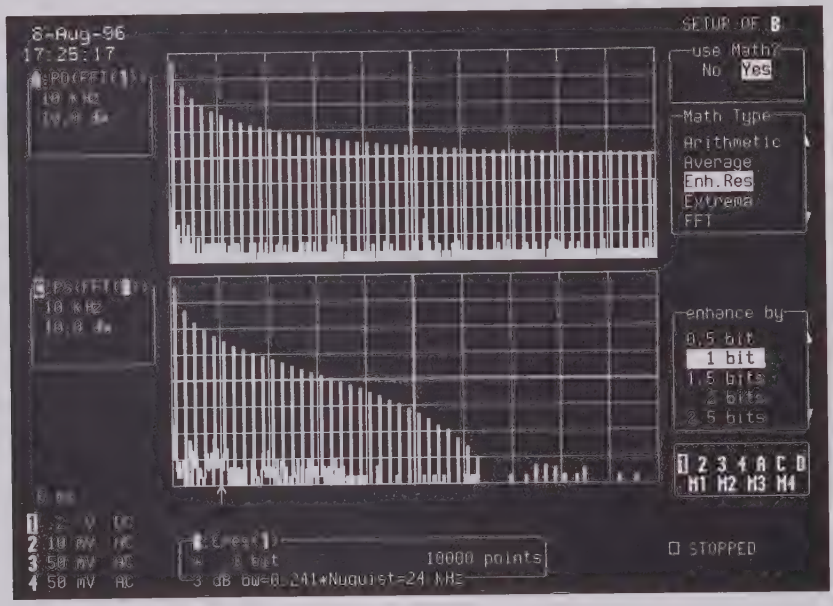
In general, enhanced resolution is used to replace the averaging function in situations where the data record has a single-shot or slowly repetitive nature and averaging cannot be used.

There are two main situations for which enhanced resolution is especially useful. One is when the signal is noticeably noisy and measurements of the noise are not required. The signal can be "cleaned up" by using the enhanced resolution function. The other is when — even if the signal is not particularly noisy — high precision measurements of the waveform are required (when using Expand with high vertical gain, for example). Enhanced resolution will then increase the resolution of the measurements.

The following examples illustrate uses for enhanced resolution.

Low-pass Filtering

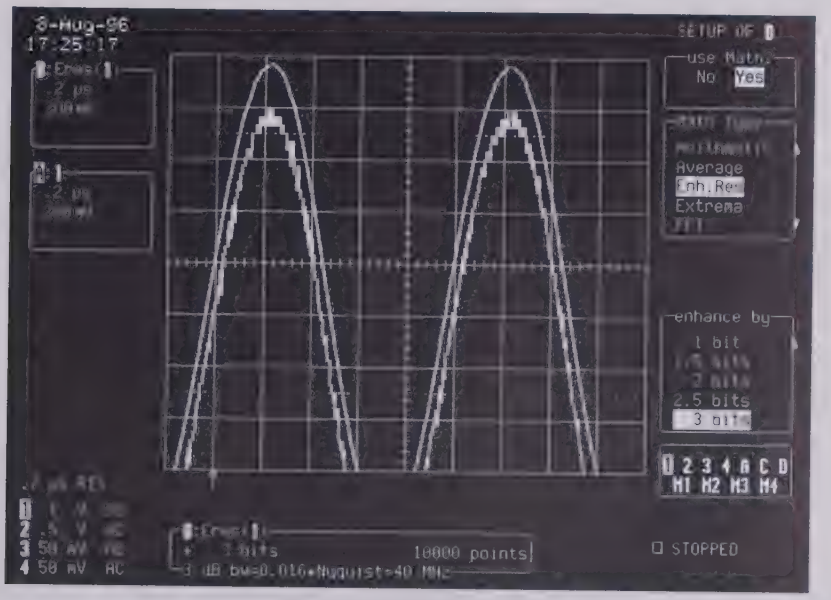
This screen shows the spectrum of a square signal before (top grid) and after (bottom grid) enhanced resolution processing. The result clearly illustrates how the filter rejects high-frequency components from the signal. The higher the bit enhancement, the lower the resulting bandwidth.



Increasing Vertical Resolution

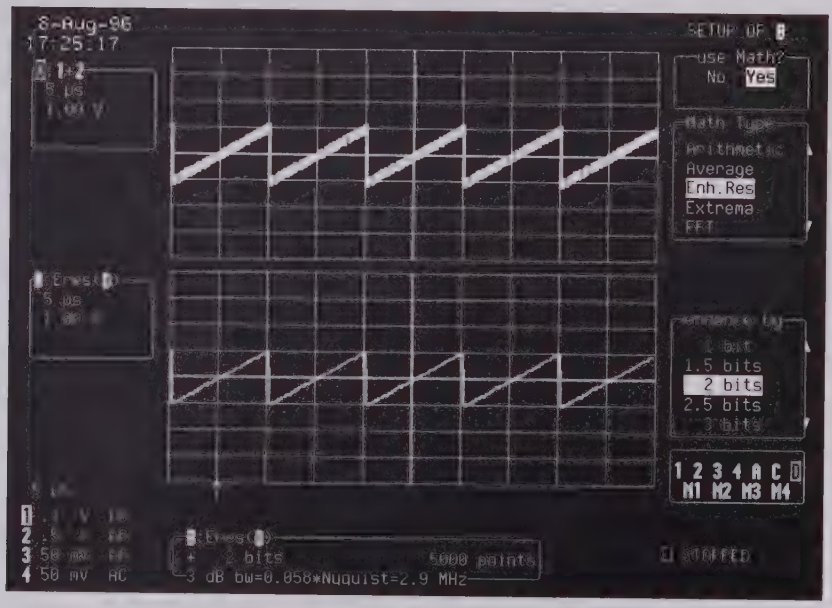
In this example the bottom trace has been significantly enhanced by a three-bit enhanced resolution function.

Note: The original signal being highly over-sampled, the resulting band width is still high enough for the signal not to be distorted.



Reducing Noise

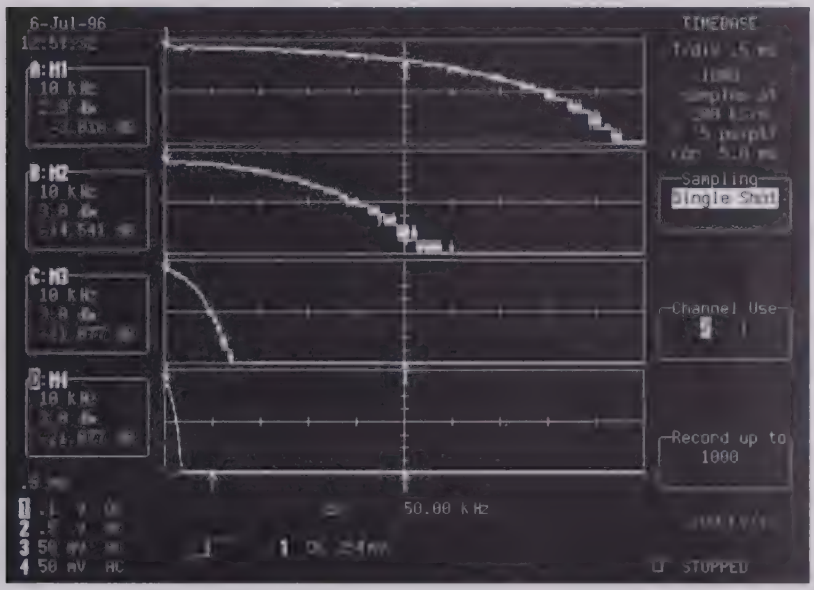
The following illustration shows the effect of enhanced resolution on a noisy signal. The original trace (top grid) has been processed by a two-bit enhanced resolution filter. The result (bottom grid) shows a "smooth" trace, where most of the noise has been eliminated.



Cautionary Notes

The enhanced resolution function can only improve the resolution of a trace; it cannot improve the accuracy or linearity of the original quantization by the eight-bit ADC.

The constraint of good temporal response excludes the use of maximally-flat filters. The passband will therefore cause signal attenuation for signals near the cut-off frequency. The highest frequencies passed may be slightly attenuated. The frequency response of a typical enhanced resolution filter (the 2-bit enhancement filter) is illustrated below, indicating the –3 dB cut-off frequency of 5.8% of the Nyquist frequency.



The filtering must be performed on finite record lengths: data will lost at the start and end of the waveform, so that the trace becomes slightly shorter after filtering.

The number of samples lost is exactly equal to the length of the impulse response of the filter used, and thus varies between two and 117 samples. Owing to the oscilloscope's very long waveform memories, this loss — just 0.2% of a 50 000 point trace — is not normally noticed. However, it is possible to demand filtering on a record so short, there would be no data output, and in this case the scope will not allow filtering.

Adding Spectrum Analysis

The FFT (Fast Fourier Transform) option WP02 adds spectrum analysis to the scope's features. The spectra of single time-domain waveforms can be computed and displayed, and power averages obtained over as many as 50 000 spectra.

Spectra are displayed with a linear frequency axis running from zero to the Nyquist frequency. The frequency scale factors (Hz/div) are in a 1–2–5 sequence. The Nyquist frequency is at the right-hand edge of the trace.

The processing equation is displayed at the bottom of the screen, together with the three key parameters that characterize an FFT spectrum:

- Transform Size N (number of input points)
- Nyquist frequency (= ½ sample rate)
- Frequency increment, Δf, between two successive points of the spectrum. These parameters are related as follows:

$$\text{Nyquist frequency} = \Delta f * N/2.$$

Note that:

$$\Delta f = 1/T,$$

where T is the duration of the input waveform record (10 * time/div).

The number of output points is equal to N/2.

Math Type

When "**FFT**" is selected from the "SETUP OF" "Math Type" menu (*Chapter 11*) the following parameters can be set.

FFT result

Power Spectrum (dBm)

The signal power (or magnitude) represented on a logarithmic vertical scale — 0 dBm corresponds to the voltage (0.316 V peak) which is equivalent to 1 mW into 50 Ω. The power spectrum is suitable for characterizing spectra which contain isolated peaks.

Power Density (dBm)

The signal power normalized to the bandwidth of the equivalent filter associated with the FFT calculation. The power density is suitable for characterizing broad-band noise.

Magnitude (same units as the input signal)

The peak signal amplitude represented on a linear scale.

Phase (degrees)

Measured with respect to a cosine whose maximum occurs at the left-hand edge of the screen, at which point it has 0 °. Similarly, a positive-going sine starting at the left-hand edge of the screen has a –90 ° phase.

Real, Imaginary, Real + Imaginary (same units as the input signal)

These represent the complex result of the FFT processing.

Maximum Points

FFT spectra are computed over the entire source time-domain waveform. This parameter limits the number of points used for FFT processing. If the input waveform contains more points than the selected maximum, they are decimated before FFT processing. But if it has fewer, all points are used.

Window Type

Chosen from the "with" menu, the window type defines the bandwidth and shape of the equivalent filter to be used in the FFT processing.

Rectangular

Normally used when the signal is:

- Transient, completely contained in the time-domain window.
- Known to have a fundamental frequency component that is an integer multiple of the fundamental frequency of the window.

Signals not corresponding to this show varying amounts of spectral leakage and scallop loss, corrected by selecting another type of window.

Hanning (Von Hann) and Hamming

Often used, they reduce leakage and improve amplitude accuracy. However, frequency resolution is also reduced.

Flat Top

This window provides excellent amplitude accuracy with moderate reduction of leakage, but also at the loss of frequency resolution.

Blackman–Harris

It reduces the leakage to a minimum, but again along with reduced frequency resolution.

See the table on page C–11 for parameters of equivalent filters.

DC AC

When "AC" is selected from the "SETUP OF" "With Window" menu (*see screen page C–8 and Chapter 11*), the DC component of the input signal is forced to zero prior to the FFT processing. This improves the amplitude resolution, especially when the input has a large DC component.

FFT Power Average

A function can be defined as the power average of FFT spectra computed by another function.

Processing Facilities

Other processing functions such as Averaging and Arithmetic can be applied to waveforms before FFT processing. Time-domain

averaging prior to FFT can be used if a stable trigger is available, thereby reducing the random noise in the signal.

To increase the FFT frequency range — the Nyquist frequency — raise the effective sampling frequency by increasing the maximum number of points or using a faster time base.

To increase the FFT frequency resolution, increase the length of the time-domain waveform record by using a slower time base.

Memory Status

— displays parameters of the waveform descriptor, including number of points, horizontal and vertical scale factors and units.

Cursors

For reading the amplitude and frequency of a data point, the **Absolute Time** cursor can be moved into the frequency domain by going beyond the right-hand edge of a time-domain waveform.

The **Relative Time** cursors can be moved into the frequency domain to simultaneously indicate the frequency difference and the amplitude difference between two points on each frequency-domain trace.

The **Absolute Voltage** cursor reads the absolute value of a point in a spectrum in the appropriate units, and the *Relative Voltage* cursors indicate the difference between two levels on each trace.

FFT Algorithms

A summary of algorithms used in the oscilloscope's FFT computation is given here for reference, as Steps 1–7.

1. If the maximum number of points is smaller than the source number of points, the source waveform data are decimated prior to the FFT. These decimated data extend over the full length of the source waveform. The resulting sampling interval and the actual transform size selected provide the frequency scale factor in a 1–2–5 sequence.

2. The data are multiplied by the selected window function.

3. FFT is computed, using a fast implementation of the DFT (Discrete Fourier Transform):

$$X_n = \frac{1}{N} \sum_{k=0}^{k=N-1} x_k \times W^{nk}$$

where

x_k is a complex array whose real part is the modified source time domain waveform, and whose imaginary part is 0.

X_n is the resulting complex frequency-domain waveform.

$W = e^{-2\pi j/N}$

N is the number of points in x_k and X_n.

The generalized FFT algorithm, as implemented here, works on N which need not be a power of 2.

4. The resulting complex vector X_n is divided by the coherent gain of the window function, in order to compensate for the loss of the signal energy due to windowing. This compensation provides accurate amplitude values for isolated spectrum peaks.

5. The real part of X_n is symmetric around the Nyquist frequency, i.e.:

   $$R_n = R_{N-n}$$

   while the imaginary part is asymmetric, i.e.:

   $$I_n = -I_{N-n}$$

   The energy of the signal at a frequency n is distributed equally between the first and the second halves of the spectrum; the energy at frequency 0 is completely contained in the 0 term.

   The first half of the spectrum (Re, Im), from 0 to the Nyquist frequency is kept for further processing and doubled in amplitude:

   $$R'_n = 2 \times R_n \qquad 0 \le n < N/2$$

   $$I'_n = 2 \times I_n \qquad 0 \le n < N/2.$$

6. The resultant waveform is computed for the spectrum type selected.

   If "**Real**", "**Imaginary**", or both are selected, no further computation is needed. The appropriate part of the complex result is given as the result (R'_n or I'_n or $R'_n + jI'_n$, as defined above).

   If "**Magnitude**" is selected, the magnitude of the complex vector is computed as:

   $$M_n = \sqrt{R'^2_n + I'^2_n}\ .$$

Steps 1–6 lead to the following result:

An AC sine wave of amplitude 1.0 V with an integral number of periods Np in the time window, transformed with the rectangular window, results in a fundamental peak of 1.0 V magnitude in the spectrum at frequency Np × Δf. However, a DC component of 1.0 V, transformed with the rectangular window, results in a peak of 2.0 V magnitude at 0 Hz.

The waveforms for the other available spectrum types are computed as follows:

Phase: angle = arctan (I_n/R_n) $M_n > M_{min}$

angle = 0 $M_n \leq M_{min}$

where M_{min} is the minimum magnitude, fixed at about 0.001 of the full scale at any gain setting, below which the angle is not well defined.

The *dBm* Power Spectrum:

$$dBm\ PS = 10 \times \log_{10}\left(\frac{M_n^2}{M_{ref}^2}\right) = 20 \times \log_{10}\left(\frac{M_n}{M_{ref}}\right)$$

where

M_{ref} = 0.316 V (that is, 0 dBm is defined as a sine wave of 0.316 V peak or 0.224 V RMS, giving 1.0 mW into 50Ω).

The dBm Power Spectrum is the same as dBm Magnitude, as suggested in the above formula.

dBm Power Density:

$$dBm\ PD = dBm\ PS - 10 \times \log_{10}\ (ENBW \times \Delta f)$$

where

ENBW is the equivalent noise bandwidth of the filter corresponding to the selected window

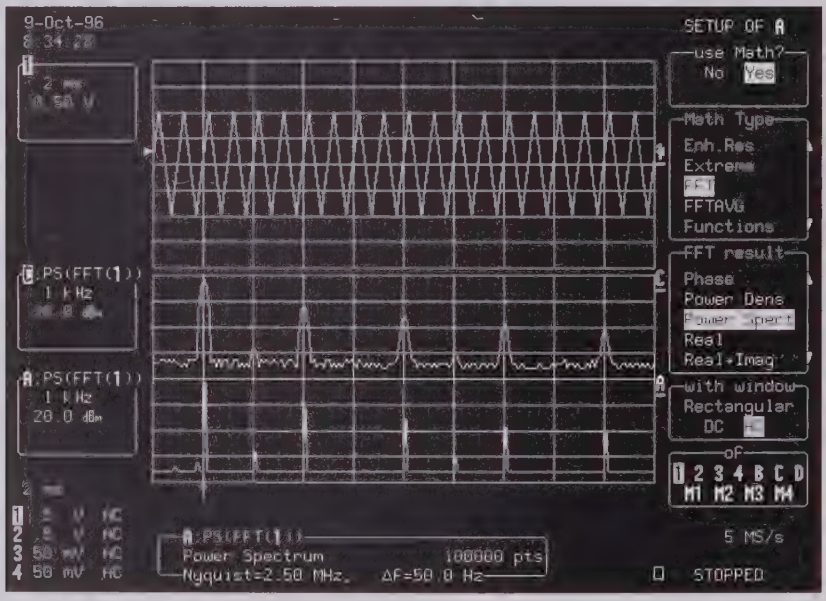
Δf is the current frequency resolution (bin width)

7. The FFT Power Average takes the complex frequency-domain data R'_n and I'_n for each spectrum generated in Step 5, and computes the square of the magnitude:

   $$M_n^2 = R'^2_n + I'^2_n,$$

   sums M_n^2 and counts the accumulated spectra. The total is normalized by the number of spectra and converted to the selected result type using the same formulae as are used for the Fourier Transform.

FFT Processing: Examples



The Effect of Windowing

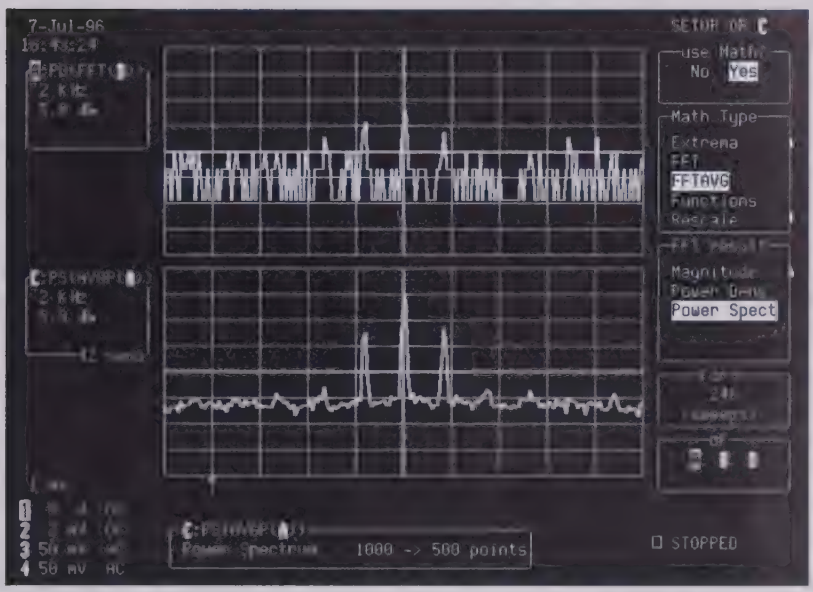
The screen above illustrates an example of spectral leakage and the use of the right window to reduce it.

Channel 1 (top trace) shows a triangular wave, of approximately 1 kHz frequency.

The bottom trace is an expansion of an FFT with a *Rectangular* window. Each peak, and especially the fundamental component at 1 kHz, influences the spectrum over a wide range of frequencies, due to the leakage of the signal power through the side lobes of the equivalent filter.

The middle trace is an expansion of another FFT of the same Channel 1 waveform, defined with the *Blackman–Harris* window.

The leakage is clearly reduced, but the peaks around the harmonics are wider. This reflects the increased bandwidth of the filter associated with this window.



The Effect of FFT Averaging

The above screen shows the FFT of a noisy signal (top trace). By applying a power average to this FFT, all incoherent noise is eliminated. The signal (Amplitude Modulation) becomes clearly visible.

FFT Glossary

Defines the terms frequently used in FFT spectrum analysis and relates them to the oscilloscope.

Aliasing

If the input signal to a sampling acquisition system contains components whose frequency is greater than the Nyquist frequency (half the sampling frequency), there will be less than two samples per signal period. The result is that the contribution of these components to the sampled waveform is indistinguishable from that of components below the Nyquist frequency. This is **aliasing**.

The timebase and transform-size should be selected so that the resulting Nyquist frequency is higher than the highest significant component in the time-domain record.

Coherent Gain

The normalized coherent gain of a filter corresponding to each window function is 1.0 (0 dB) for a rectangular window and less than 1.0 for other windows. It defines the loss of signal energy due to the multiplication by the window function. This loss is compensated in the oscilloscope. *The table on the following page lists the values for the implemented windows.*

ENBW (Equivalent Noise Bandwidth)

ENBW is the bandwidth of a rectangular filter (same gain at the center frequency), equivalent to a filter associated with each frequency bin, which would collect the same power from a white noise signal. In the table below, ENBW is listed for each window function implemented and is given in bins.

Window Frequency-Domain Parameters				
Window type	Highest Side Lobe (dB)	Scallop Loss (dB)	ENBW (bins)	Coherent Gain (dB)
Rectangular	–13	3.92	1.0	0.0
von Hann	–32	1.42	1.5	– 6.02
Hamming	–43	1.78	1.37	–5.35
Flat-Top	–44	0.01	2.96	–11.05
Blackman–Harris	–67	1.13	1.71	–7.53

Filters

Computing an N-point FFT is equivalent to passing the time-domain input signal through N/2 filters and plotting their outputs against the frequency. The spacing of filters is $\Delta f = 1/T$ while the bandwidth depends on the window function used (see Frequency bins).

Frequency bins

The FFT algorithm takes a discrete source waveform, defined over N points, and computes N complex Fourier coefficients, which are interpreted as harmonic components of the input signal.

For a real source waveform (imaginary part equals 0), there are only N/2 independent harmonic components.

An FFT corresponds to analyzing the input signal with a bank of N/2 filters, all having the same shape and width, and centered at N/2 discrete frequencies. Each filter collects the signal energy that falls into the immediate neighborhood of its center frequency, and thus it can be said that there are N/2 "frequency bins".

The distance in hertz between the center frequencies of two neighboring bins is always:

$$\Delta f = 1/T,$$

where T is the duration of the time-domain record in seconds.

The width of the main lobe of the filter centered at each bin depends on the window function used. The rectangular window has a nominal width at 1.0 bin. Other windows have wider main lobes (*see table*).

Frequency Range

The range of frequencies computed and displayed is 0 Hz (displayed at the left-hand edge of the screen) to the Nyquist frequency (at the rightmost edge of the trace).

Frequency Resolution

In a simple sense, the frequency resolution is equal to the bin width Δf. That is, if the input signal changes its frequency by Δf, the corresponding spectrum peak will be displaced by Δf. For smaller changes of frequency, only the shape of the peak will change.

However, the effective frequency resolution (i.e. the ability to resolve two signals whose frequencies are almost the same) is further limited by the use of window functions. The ENBW value of all windows other than the rectangular is greater than Δf and the bin width. *The table lists the ENBW value for the implemented windows.*

Leakage

In the power spectrum of a sine wave with an integral number of periods in the (rectangular) time window (i.e. the source frequency equals one of the bin frequencies), the spectrum contains a sharp component whose value accurately reflects the source waveform's amplitude. For intermediate input frequencies this spectral component has a lower and broader peak.

The broadening of the base of the peak, stretching out into many neighboring bins is termed **leakage**. It is due to the relatively high side lobes of the filter associated with each frequency bin.

The filter side lobes and the resulting leakage are reduced when one of the available window functions is applied. The best reduction is provided by the *Blackman–Harris* and *Flat Top* windows. However, this reduction is offset by a broadening of the main lobe of the filter.

Numbers of Points

FFT is computed over the number of points (Transform Size) whose upper bounds are the source number of points, and by the maximum number of points selected in the menu. FFT generates spectra of N/2 output points.

Nyquist Frequency

The Nyquist frequency is equal to one half of the effective sampling frequency (after the decimation): $\Delta f \times N/2$.

Picket Fence Effect

If a sine wave has a whole number of periods in the time domain record, the power spectrum obtained with a rectangular window will have a sharp peak, corresponding exactly to the frequency and amplitude of the sine wave. Otherwise the spectrum peak with a rectangular window will be lower and broader.

The highest point in the power spectrum can be 3.92 dB lower (1.57 times) when the source frequency is halfway between two discrete bin frequencies. This variation of the spectrum magnitude is called the **picket fence effect** (the loss is called the scallop loss).

All window functions compensate this loss to some extent, but the best compensation is obtained with the *Flat Top* window (*see table*).

Power Spectrum

The power spectrum (V^2) is the square of the magnitude spectrum.

The power spectrum is displayed on the dBm scale, with 0 dBm corresponding to:

$$Vref^2 = (0.316\ Vpeak)^2,$$

where Vref is the peak value of the sinusoidal voltage, which is equivalent to 1 mW into 50 Ω.

Power Density Spectrum

The power density spectrum (V^2/Hz) is the power spectrum divided by the equivalent noise bandwidth of the filter in hertz.

The power density spectrum is displayed on the dBm scale, with 0 dBm corresponding to ($Vref^2/Hz$).

Sampling Frequency

The time-domain records are acquired at sampling frequencies dependent on the selected time base.

Before the FFT computation, the time-domain record may be decimated. If the selected maximum number of points is lower than the source number of points, the effective sampling frequency is reduced.

The effective sampling frequency equals twice the Nyquist frequency.

Scallop Loss

Loss associated with the picket fence effect (see table).

Window Functions

All available window functions belong to the sum of cosines family with one to three non-zero cosine terms:

$$W_k = \sum_{m=0}^{m=M-1} a_m \cos\left(\frac{2pk}{N} m\right) \qquad 0 \le k < N,$$

where:

$M = 3$	is the maximum number of terms
a_m	are the coefficients of the terms
N	is the number of points of the decimated source waveform, and
k	is the time index.

The following table lists the coefficients a_m. The window functions seen in the time domain are symmetric around the point k = N/2

Coefficients Of Window Functions			
Window type	**a0**	**a1**	**a2**
Rectangular	1.0	0.0	0.0
von Hann	0.5	–0.5	0.0
Hamming	0.54	–0.46	0.0
Flat-Top	0.281	–0.521	0.198
Blackman-Harris	0.423	–0.497	0.079

Error Messages

One of the following FFT-related error messages may be displayed at the top of the screen.

"Incompatible input record type"	FFT power average is defined only on a function defined as FFT.
"Horizontal units don't match"	FFT of a frequency-domain waveform is not available.
"FFT source data zero filled"	If there are invalid data points in the source waveform (at the beginning or at the end of the record), these are replaced by zeros before FFT processing.
"FFT source data over/underflow"	The source waveform data has been clipped in amplitude, either in the acquisition — gain too high or inappropriate offset — or in previous processing. The resulting FFT contains harmonic components which would not be present in the unclipped waveform. The settings defining the acquisition or processing should be changed to eliminate the over/underflow condition.
"Circular computation"	A function definition is circular (i.e. the function is its own source, indirectly via another function or expansion). One of the definitions should be changed.

References

Bergland, G.D., *A Guided Tour of the Fast Fourier Transform*, IEEE Spectrum, July 1969, pp. 41–52.

A general introduction to FFT theory and applications.

Harris, F.J., *On the Use of Windows for Harmonic Analysis with the Discrete Fourier Transform*, Proceedings of the IEEE, vol. 66, No. 1, January 1978, pp. 51–83.

Classical paper on window functions and their figures of merit, with many examples of windows.

Brigham, E.O., *The Fast Fourier Transform*, Prentice Hall, Inc., Englewood Cliffs, N.J., 1974.

Theory, applications and implementation of FFT. Includes discussion of FFT algorithms for N not a power of 2.

Ramirez, R.W., *The FFT Fundamentals and Concepts*, Prentice Hall, Inc., Englewood Cliffs, N.J., 1985.

Practice-oriented, many examples of applications.

Formulating Parameters

Parameter measurements are based on recommendations of the IEEE Std 181-1977 *Standard on Pulse Measurement and Analysis by Objective Techniques;* terminology is derived from the ANSI/IEEE Std 194-1977 *Standard Pulse Terms and Definitions.*

Voltage Measurements

Base and top magnitudes are assigned in order to find magnitude reference crossings, with the method employed following IEEE Std 181-1977. The magnitude histogram of the waveform within the cursor window is created. It is searched for dominant magnitude populations. If no two dominant populations can be found, the minimum and the maximum of the distribution are used. Of the two magnitudes, the lowest in the cursor window is assigned to the *Base* line and the highest to the *Top* line.

Amplitude is measured by the absolute difference between Base and Top.

Maximum determines the maximum voltage within the area defined by the cursors.

Minimum determines the minimum voltage within the area defined by the cursors.

Peak to Peak value	= Maximum – Minimum
Overshoot positive	= (Maximum – Top) / Amplitude
Overshoot negative	= (Minimum – Base) / Amplitude

PULSE PARAMETERS

Note for Computing Values

The number of data values used for computing Mean, Standard Deviation, RMS, and Area values depends on the identification of a periodic waveform.

If one or more periods are identified, a sub-window is used which starts at the first mesial point (50% magnitude transition) and ends at the last mesial point on a leading edge in the original window (i.e. in the formulae below, N = the number of data points within the periods found up to a maximum of 100 periods).

In all other cases, Mean, Standard Deviation, RMS, and Area are evaluated using all data points inside the cursor window. In the following, v_i denotes the measured sample values.

Mean determines the average value of all the data points selected as described above.

$$\frac{1}{N}\sum_{i=1}^{N} v_i$$

Standard Deviation (Sdev) is the standard deviation of the measured points from the mean. It is calculated from the following formula:

$$\sqrt{\frac{1}{N}\sum_{i=1}^{N}(v_i - mean)^2}$$

RMS is derived from the square root of the average of the squares of the magnitudes, for all the data as described above.

$$\sqrt{\frac{1}{N}\sum_{i=1}^{N}(v_i)^2}$$

The **Area** covered by the signal is computed from the sum over all the data points selected, as described above, times the sample interval.

Time Measurements

Note: For time measurements it is necessary to distinguish between magnitude crossings occurring on leading edges and those occurring on trailing edges. In the equations below the following notation has been used:

Ml = *number of leading edges found*

Mt = *number of trailing edges found*

Tl_i^x = *time when leading edge i crosses the x% level*

Tt_i^x = *time when trailing edge i crosses the x% level*

All times are linearly interpolated between two measured points.

Period is calculated from the average length of the full periods of the waveform within the selected interval. A full period is the time measured between the first and third 50% crossing points, the third and fifth, the fifth and seventh, etc.

$$\frac{1}{Ml-1}\sum_{i=1}^{Ml-1}\left(Tl_{i+1}^{50}-Tl_{i}^{50}\right)$$

Frequency is then calculated as 1/Period.

Cycles gives the number of periods found.

Pulse Width (Width) determines the duration between the **Pulse Start** (mesial point, i.e. the 50% magnitude transition point, on the leading edge) and the **Pulse Stop** (mesial point on the trailing edge) of a pulse waveform. Like the pulse start, the pulse stop is a 50% magnitude reference point.

$$\frac{1}{Mt}\sum_{i=1}^{Mt}\left(Tt_{i}^{50}-Tl_{i}^{50}\right)$$

Delay is the time from the trigger point to the first 50% transition crossing, i.e. the **Pulse Start.**

$$Tl_{i}^{50}$$

Duty Cycle measures the Pulse Width as a percentage of the Pulse Period.

Risetime (Rise) measures the time of a pulse waveform's transition with a positive slope.

Falltime (Fall) measures the time of a pulse waveform's transition with a negative slope.

For both risetime and falltime measurements the instrument determines the duration between the proximal point (10% magnitude transition) and the distal point (90% magnitude transition) on leading edges and the duration between the distal point and the proximal point on trailing edges:

leading edge duration =

$$\frac{1}{Ml}\sum_{i=1}^{Ml}\left(Tl_i^{90} - Tl_i^{10}\right)$$

trailing edge duration =

$$\frac{1}{Mt}\sum_{i=1}^{Mt}\left(Tt_i^{10} - Tt_i^{90}\right)$$

Depending on the sign of the slope of the leading edge transition, the instrument then assigns either:

for positive slope:	Risetime	=	leading edge duration
	Falltime	=	trailing edge duration
for negative slope:	Risetime	=	trailing edge duration
	Falltime	=	leading edge duration

Cyclic Parameters

Cyclic category parameters are determined from the first 50 full waveform cycles displayed. If more than 50 cycles are displayed, only the first 50 full cycles will be used.

Cyclic Category Parameters	
cmean	cmedian
crms	csdev
cycles	duty
freq	period

Using ASCII-Stored Files

The ASCII waveform storage feature allows waveforms traditionally stored to a Mass-Memory device in a binary format to be stored in one of several ASCII formats, each tailored for a commonly used analysis package. The user-interface changes to support ASCII waveform storage are found in the STORE menu (*see Chapter 15*).

Note that waveforms stored in ASCII cannot be recalled back into the scope.

The basic layout of the five formats is summarized in the table:

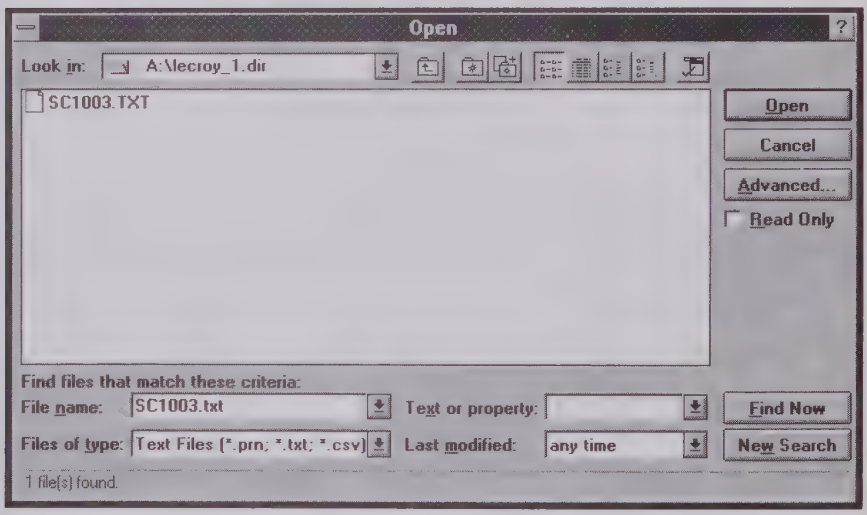
Format	Header	Time Values	Amplitude Values	Sequence Times	Multi-Segment	Dual Array
Spreadsheet	Yes	Yes	Yes	Yes	Yes	Yes
MathCad™	Yes	Yes	Yes	Yes	Yes	??
MATLAB™	No	No	Yes	No	Yes	No

Header	Format includes some form of header before the data.
Time Values	Format stores time values along with each amplitude value.
Amplitude Values	Format stores amplitude values.
Sequence Times	Header contains the sequence time information for each segment of a sequence.
Multi-Segment	Format concatenates multiple segments of a sequence waveform.
Dual Array	Format allows dual-array data (i.e. Extrema, or complex FFT) to be stored.

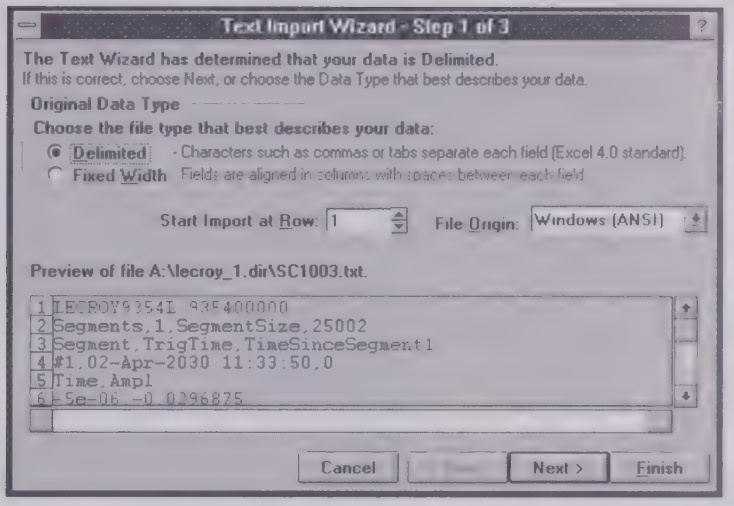
Examples of the use of each of the three formats are given on the following pages.

Example: Spreadsheet Format with *Excel*

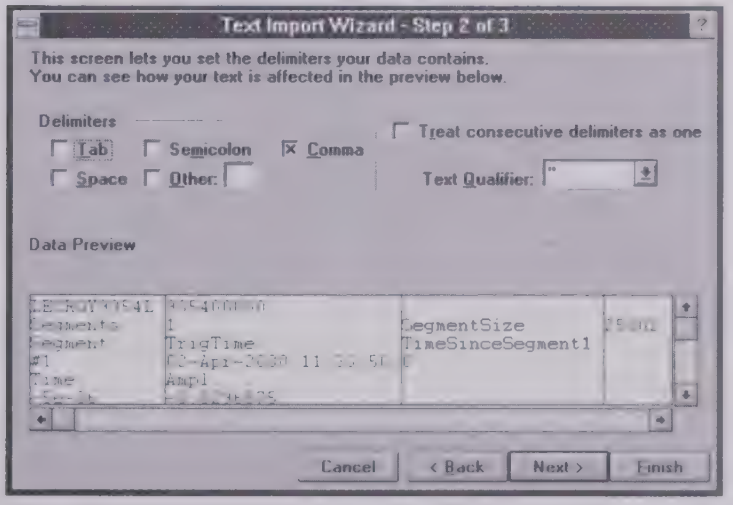
This example was created using Microsoft *Excel, Version 7.0,* for *Windows 95.* A waveform stored in Spreadsheet format may be read into Microsoft Excel using the File -> Open dialog as follows:

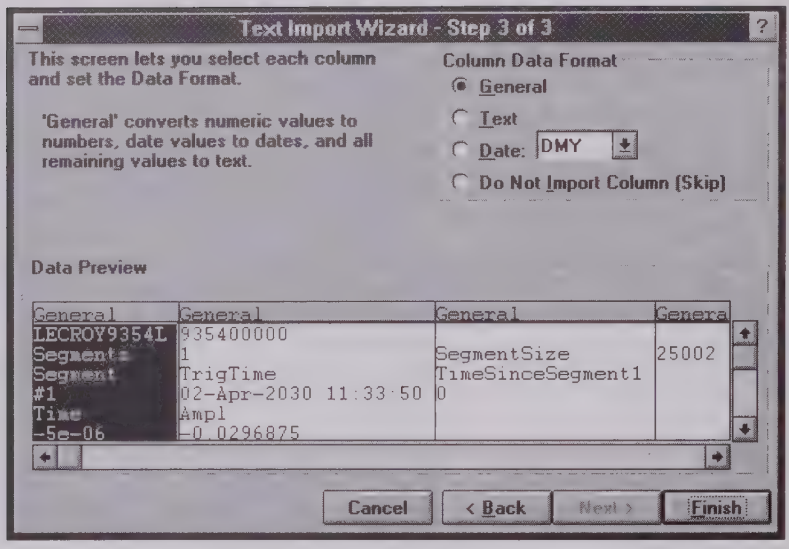


Excel will now ask for more information about the file type. Ensure that the 'Delimited' option is selected in the first step of the Wizard.


Text Import Wizard - Step 1 of 3
The Text Wizard has determined that your data is Delimited.
If this is correct, choose Next, or choose the Data Type that best describes your data.
Original Data Type
Choose the file type that best describes your data:
Delimited - Characters such as commas or tabs separate each field (Excel 4.0 standard).
Fixed Width Fields are aligned in columns with spaces between each field
Start Import at Row: 1
File Origin: Windows (ANSI)
Preview of file A:\lecroy_1.dir\SC1003.txt.
1 LECROY9354L 935400000
2 Segments,1,SegmentSize,25002
3 Segment,TrigTime,TimeSinceSegment1
4 #1,02-Apr-2030 11:33:50,0
5 Time,Ampl
6 -5e-06,-0.0296875
Cancel
Next >
Finish

The next step allows the specific delimiter to be specified. The Spreadsheet format generated by the scope uses a Comma to delimit columns. Ensure that this is selected.





The third and final step allows the format of the columns to be specified. The 'General' format for each column should be used (this is the default).

After clicking the Finish button the a display similar to that following should be displayed.

Microsoft Excel - SC1001.TXT

File Edit View Insert Format Tools Data

	A	B	C	D
1	LECROY9354L	935400000		
2	Segments	1	SegmentSize	502
3	Segment	TrigTime	TimeSinceSegment1	
4	#1	22.03.30 20:22	0	
5	Time	Ampl		
6	-5.01E-05	-0.00755		
7	-4.99E-05	-0.00755		
8	-4.97E-05	-0.00755		
9	-4.95E-05	-0.00755		
10	-4.93E-05			

Plotting a Single-Segment Waveform

Plotting the data from a single-segment waveform requires the use of a scatter plot based on the data in the first two columns with the first column used as the X values.

Extracting Segments from Sequence Waveforms

The header created for the Spreadsheet format contains all the information required to extract various elements of a sequence waveform. The following Formulae may be used to extract information such as the start and end row of the data for a given segment, or the trigger time of a given segment.

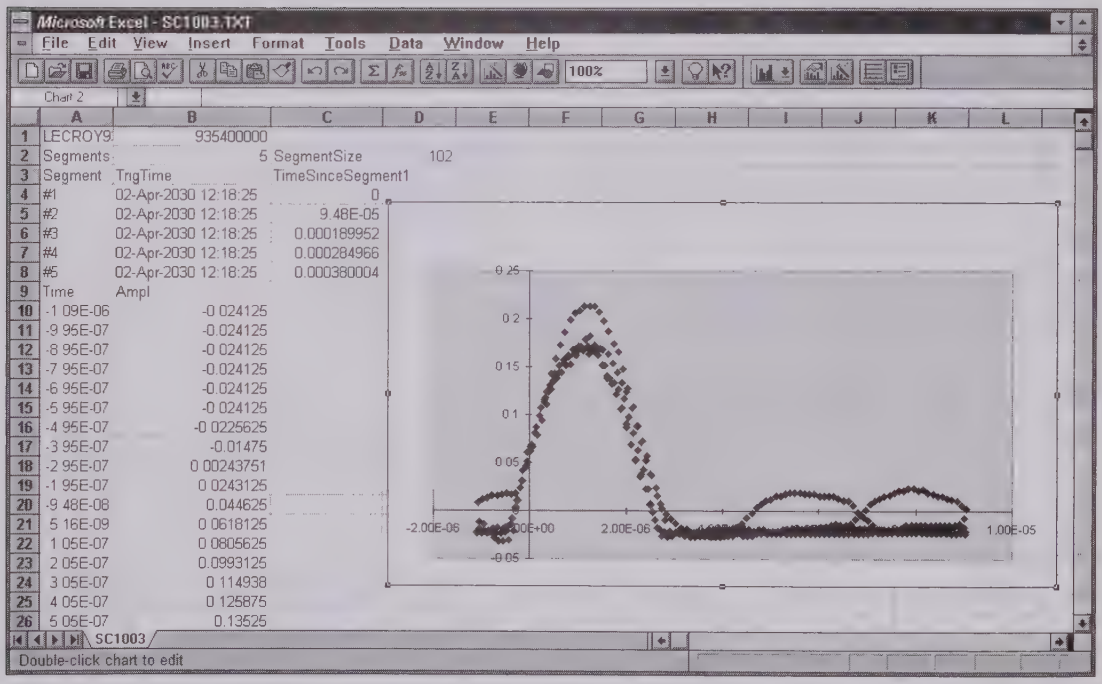
SegmentStartRow := (*DesiredSegment* * D2) + B2 + 5

SegmentEndRow := *SegmentStartRow* + D2 -1

TrigTime= INDIRECT(ADDRESS(*DesiredSegment* +3;2;4))

TimeSinceFirstTrig= INDIRECT(ADDRESS(*DesiredSegment* +3;3;4))

Plotting the data from all segments using a scatter plot will result in all segments overlaid (similar to the scope's display of sequence traces in persistence mode).



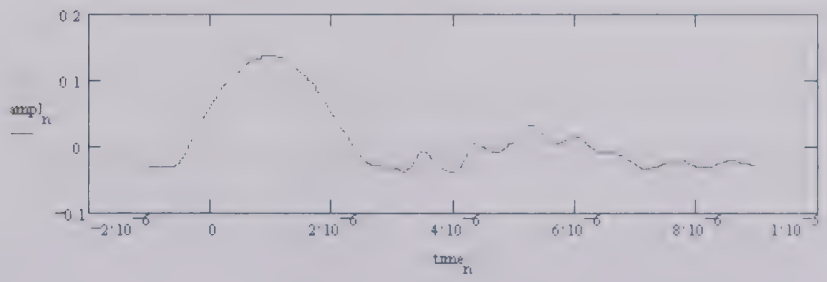
	A	B	C
1	LECROY9	935400000	
2	Segments	5	SegmentSize 102
3	Segment	TrigTime	TimeSinceSegment1
4	#1	02-Apr-2030 12:18:25	0
5	#2	02-Apr-2030 12:18:25	9.48E-05
6	#3	02-Apr-2030 12:18:25	0.000189952
7	#4	02-Apr-2030 12:18:25	0.000284966
8	#5	02-Apr-2030 12:18:25	0.000380004
9	Time	Ampl	
10	-1 09E-06	-0 024125	
11	-9 95E-07	-0.024125	
12	-8 95E-07	-0 024125	
13	-7 95E-07	-0.024125	
14	-6 95E-07	-0.024125	
15	-5 95E-07	-0 024125	
16	-4 95E-07	-0 0225625	
17	-3 95E-07	-0.01475	
18	-2 95E-07	0 00243751	
19	-1 95E-07	0 0243125	
20	-9 48E-08	0.044625	
21	5 16E-09	0 0618125	
22	1 05E-07	0 0805625	
23	2 05E-07	0.0993125	
24	3 05E-07	0 114938	
25	4 05E-07	0 125875	
26	5 05E-07	0.13525	

Example: *MathCad*

This example was created using MathSoft's *MathCad*™, *Version 3.1*, for *Windows*.

Reading & Graphing the file — Single-Segment Version

a := READPRN(sc1004)	Read data from file sc1004.prn into matrix 'a'
$n := 2 .. \langle 1 + a_{0,1} \rangle$	Create ramp over all rows containing data
time := $a^{\langle 0 \rangle}$	Extract time vector
ampl := $a^{\langle 1 \rangle}$	Extract amplitude vector



— Multi-Segment Version

The following *MathCad* example demonstrates how to extract data from a given segment. The data used for this example consisted of two segments of three samples each, allowing the entire imported matrix to be shown.

Read data from file

$a := READPRN(sc1000)$

$$a = \begin{bmatrix} 2 & 3 \\ 1 & 0 \\ 2 & 999 \\ 1 & 1 \\ 1.1 & 2 \\ 1.2 & 3 \\ 1 & 1.1 \\ 1.1 & 2.1 \\ 1.2 & 3.1 \end{bmatrix}$$

Extracting the first segment only (or only segment if not sequence trace)

$n := (1 + a_{0,0}) .. (a_{0,0} + a_{0,1})$

$n = \begin{bmatrix} 3 \\ 4 \\ 5 \end{bmatrix}$

$m := 0 .. 1$

$firstseg_{n-1-a_{0,0},m} := a_{n,m}$

$$firstseg = \begin{pmatrix} 1 & 1 \\ 1.1 & 2 \\ 1.2 & 3 \end{pmatrix}$$

Extracting a given segment

$numsegments := a_{0,0}$ Total number of segments in trace

$seglen := a_{0,1}$ Number of samples in each segment

$segment := 0$ Desired segment number

$segstart := 1 + numsegments + segment \cdot seglen$ Index of first point in segment

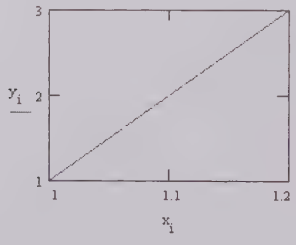
$segend := segstart + seglen - 1$ Index of last point in segment

$segtime := a_{segment+1,1}$ Segment trigger time

$x := a^{\langle 0 \rangle}$

$y := a^{\langle 1 \rangle}$

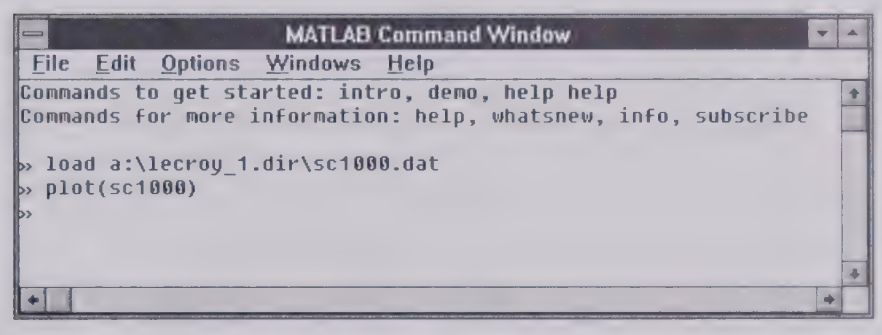
$i := segstart .. segend$

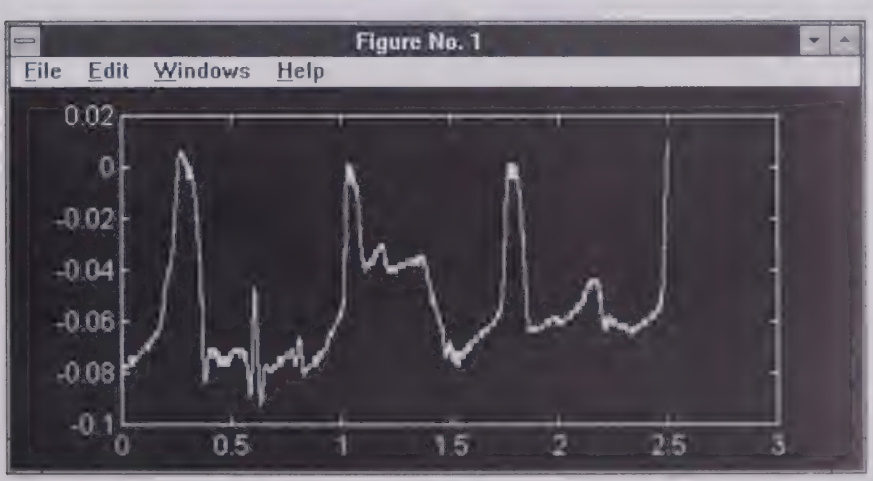


Example: *MATLAB*

This example was created using MathWorks' *MATLAB™ Version 4.2c.1* for *Windows*.

Reading and graphing a waveform in *MATLAB* may be achieved with two simple commands, as the following example shows. The first command loads the file into a matrix which is automatically named after the file. The second command plots this matrix.


MATLAB Command Window
File Edit Options Windows Help
Commands to get started: intro, demo, help help
Commands for more information: help, whatsnew, info, subscribe
» load a:\lecroy_1.dir\sc1000.dat
» plot(sc1000)
»



Detailed Description of the Formats

Spreadsheet

Format

Note: Fields in bold type are constants that are present in the output file as shown. Fields in italic are variables that are filled in when the file is written.

<scopeid>,	*<scopeserial>*	
Segments,	*<numseg>*,	**SegmentSize,** *<numpts>*
Segment,	**TrigTime,**	**TimeSinceFirstSegment**
#1,	<trigtime(1)>,	**0.0**
...	...	
#<numseg>,	<trigtime(*numseg*)>,	<trigdelta(*numseg*)>
Time,	**Ampl,**	**[Ampl1]**
x(0),	*y(0)*,	*[y1(0)]*
x(1),	*y(1)*,	*[y2(0)]*
...	...	
*x(numgseg*numpts)*,	*y(numseg*numpts)*,	*[y1(numseg*numpts)]*

Single-Segment Example

```
LECROY9354,935412345
Segments,1,SegmentSize,502
Segment,Trig Time,TimeSinceFirstSegment
#1,21 Mar 1990 9:37:08,0.0
Time,Ampl
0.0,1
0.1,2
...
```

Multi-Segment Example

```
LECROY9354,935412345
Segments,3,SegmentSize,502
Segment,Trig Time,TimeSinceFirstSegment
#1,21 Mar 1990 9:37:08,0.0
#2,21 Mar 1990 9:37:13,5.0
#3,21 Mar 1990 9:37:15,7.0
Time,Ampl
0.0,1
0.1,2
...
0.0,1.1
0.0,2.1
...
0.0,1.05
0.0,2.05
```

Dual-Array Example

```
LECROY9354,935412345
Segments,1,SegmentSize,502
Segment,Trig Time,TimeSinceFirstSegment
#1,21 Mar 1990 9:37:08,0.0
Time,Ampl
0.0,1.1,1.1
0.1,2.1,2.1
...
```

Notes

The basic structure of the Spreadsheet format is a header containing scope identification information, followed by a block containing trigger times for multi-segment waveforms, followed by the data itself.

This format is compatible with the ASCII import of the LeCroy LW4xx Arbitrary Function Generator.

MathCad

Format

<"scopeid">
<"TriggerTime">

<numseg>	*<numpts>*	
Segment	**TimeSinceFirstSegment**	
1	0.0	
...	...	
<numseg>	<trigdelta(*numseg*)>	
Time	**Ampl**	**Ampl1**
<x(0)>	*<y(0)>*	*[<y1(0)>]*
<x(1)>	*<y(1)>*	*[<y1(1)>]*
...	...	
*<x(numgseg*numpts)>*	*<y(numseg*numpts)>*	
	*[<y1(numseg*numpts)>]*	

Single-Segment Example

```
"LECROY9354,935412345"
"23-March-90,12:44:23"
1               502
Segment         TimeSinceFirstSegment
1               0.0
Time            Ampl
0.0             1
0.1             2
.....
```

Multi-Segment Example

```
"LECROY9354,935412345"
"23-March-90,12:44:23"
3               502
Segment         TimeSinceFirstSegment
1               0.0
2               5.0
3               7.0
Time            Ampl
0.0             1
0.1             2
.....
0.0             1.1
0.1             2.1
.....
0.0             1.05
0.1             2.05
```

Notes

The format created for MathCad is very similar to the Spreadsheet format, but with some differences due to the way MathCad interprets the header information.

One of the most important of these is that the absolute trigger time is only given for the first segment, with relative times (in units of seconds) being included for each segment.

Another difference is that the scope identification and trigger time are wrapped in quotes to ensure that MathCad does not attempt to import them.

MATLAB Files

Format

y(0)
y(1)
...
*y(numseg*numpts)*

Single Segment Example

```
1.0
1.1
1.2
...
4.5
```

Notes

MATLAB supports a very simple format, without header information, and with amplitude values only. Multiple segments will be appended with no separator. And just one value from the pair of amplitude values present in a dual-array will be stored.

***Note:** Index entry page numbers are prefixed by chapter numbers (1–1, 1–2, 2–3, 2–4 and so on). While "A", "B", "C", "D" and "E" prefixes denote pages in the respective appendices.*

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Australia: Philips Test and Measurement
2 9888 8222
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0316 3070
Benelux: LeCroy Europe GmbH
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Brazil: ATP/Hi-Tek Electronica Ltda
11 725 5822
Canada: Allan Crawford Assoc. Ltd.
Mississauga: 905 890 2010
N. Vancouver: 604 878 1002
Chile: Sistemas de Instrumentacion Ltda
2 6951137
Denmark: Lutronic ApS
43 42 9764
Eastern Europe: Elsinco GmbH, Vienna
1 815 04 00
Finland: Orbis OY, 0478 830
France: LeCroy Sarl,
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Mexico: Electroingenieria de Precision SA
559 7677
New Zealand: Philips Test and Measurement
649 8494 160
Norway: Avantec AS
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